Martin Bend
Wetland Management Plan

July 2006

BBLAP

Government of South Australia

South Australian Murray-Darling Basin Natural Resources Management Board

This management plan was written by Hugh Robertson for the Berri Barmera Local Action Planning Committee, and reviewed and endorsed by the SA River Murray Wetland Technical Group.

Funding was provided by the National Action Plan for Salinity and Water Quality, the National Heritage Trust, and the South Australian Murray Darling Basin Natural Resources Management Board.

The management plan has been prepared according to the *Guidelines for developing wetland management plans for the River Murray in South Australia 2003* (DWLBC 2003) and as such fulfils obligations under the Water Allocation Plan for the River Murray Prescribed Watercourse.

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Cover photos:
Inundation of temporary wetland habitat in Martin Bend (Photos: Hugh Robertson, November 2005)

Community endorsement of the Martin Bend Wetland Management Plan

Since 1998 the Berri Barmera Local Action Planning Committee (LAP), Martin Bend Steering Committee, Berri Lions Club and the Berri Barmera Council have been implementing management actions for the enhancement of the values of the wetland and floodplain areas of Martin Bend.

The Berri Barmera LAP has been working in collaboration with the Berri Barmera Council, Berri Lions Club, South Australian Murray-Darling Basin Natural Resources Management Board and the Department for Water, Land and Biodiversity Conservation to develop the Martin Bend Wetland Management Plan.

We are pleased to present the Martin Bend Wetland Management Plan for accreditation and application for a long-term allocation water licence.

Paul Stribley

Project Manager
Berri Barmera Local Action Planning Committee

Note:
This Wetland Management Plan encompasses both the floodplain and wetland areas in Martin Bend.

Within the text 'Martin Bend' refers to the wetland-floodplain complex as a whole, whereas 'wetland' and 'lagoon' only refer to the wetland areas. 'Floodplain' refers to the area of higher elevation inundated during flood events.

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INTRODUCTION

In 1998 a management plan for Martin Bend was produced by consultants ID&A (South Australia) for the Berri Barmera Local Action Planning Committee (BBLAP). The 1998 Management Plan provided an initial focus for community members, including Berri Lions Club, to manage the land and water resources in Martin Bend.

On the 1st July 2002, the Minister for the Environment and Conservation adopted the Water Allocation Plan for the River Murray Prescribed Watercourse. In doing so, a water allocation of 200 GL of South Australia's entitlement flow of 1850 GL per annum was endorsed for wetlands along the River Murray. To obtain a water allocation, individual community groups are required to submit a Wetland Management Plan that meets the criteria in the 'Guidelines for Developing Wetland Management Plans for the River Murray in South Australia' ('Guideline') report (DWLBC 2003).

This Martin Bend Wetland Management Plan has been upgraded to meet the criteria set out in the Guideline report.

What are the environmental, social and cultural significances of Martin Bend?

Martin Bend is situated adjacent to the River Murray on the outskirts of Berri, and is a wetland of high social and aesthetic value to the local community. Martin Bend also represents a site of significant ecological value, due to the habitat it provides for native flora and fauna communities. The location of Martin Bend adjacent to the River Murray suggests the wetland would also have been a significant site for local indigenous communities, particularly for the food and other resources the wetland provided.

Martin Bend is a wetland that is highly visible to the local community and visitors. Public access is not restricted and the area attracts numerous visitors, which utilise the wetland for activities such as bird watching and walking, and access the River Murray for fishing, boating and camping. The walking trail in Martin Bend regularly attracts groups and individuals and is recognised as an important recreational resource.

Sustainable management of the water regime and environmental values of Martin Bend is important to provide the aesthetic values sought by visitors, and because the wetland acts as an educational tool to inform the community about wetland management.

Martin Bend contains five wetlands - these include one permanent lagoon, three temporary lagoons, and a stormwater and drainage disposal basin. These wetlands all have different water regimes, which create significant habitat diversity for native flora and fauna, including wetland birds and frogs.

The permanent lagoon in Martin Bend functioned as a permanent wetland for over 70 years. The water level in the permanent lagoon was maintained by the Lock 4 weir pool on the River Murray (weir construction completed in 1929). However, over the past 5 years the permanent lagoon has often been disconnected from the River Murray.

Martin Bend has been identified in the *Wetlands Atlas of the South Australian Murray Valley* (Jensen *et al*. 1996) and in *River Murray Wetland: their characteristics, significance and management* (Thompson 1986) as a wetland of high priority for management.

Although Martin Bend is degraded due to high salinity and an altered wetting and drying regime, the wetland supports native vegetation communities and aquatic habitat, including open water used by wetland birds, and woodland and shrubby vegetation on the floodplain (Appendix 15).

Why does Martin Bend need a Wetland Management Plan?

There are a number of threats to the long-term sustainability of Martin Bend. For example, the accumulation of salt in the wetland impacts on native flora and fauna communities, and poses a risk to water quality in the River Murray. The lack of frequent flood events and availability of water for wetland conservation also threatens the survival of trees including River Red Gums (*Eucalyptus camaldulensis*).

These issues highlight the need for a coordinated and scientifically-informed approach to the management of Martin Bend.

Berri Barmera LAP, the Martin Bend Steering Committee, Martin Bend Wetland Group and the Berri Lions Club have initiated a number of management actions, including installing a regulator to manage the water level and the development of a walking trail. However, the lack of a detailed management plan limits the capacity to manage the ecological, social and cultural values of Martin Bend.

This Martin Bend Wetland Management Plan establishes clear management objectives to improve the biological and physical health of the wetland, and promote community and visitor activities. This Management Plan describes the physical and ecological features of Martin Bend, and describes the threats to the wetland such as increased salinity and altered water regime.

This Wetland Management Plan also outlines the management actions and monitoring program for Martin Bend.

MISSION STATEMENT

To maintain and rehabilitate wetland habitat in Martin Bend through management of a wetting and drying regime in the wetland, and provide a high value recreational and environmental education resource for the local community.

VISION STATEMENT

The vision for Martin Bend is to increase the frequency of environmental flows in the permanent and temporary lagoons, providing habitat for native fauna and conditions suitable for the regeneration of native vegetation. Works to maintain and promote use of the walking trail and visitor facilities around the wetland will be a priority, which aims to increase community awareness of wetland management.

MANAGEMENT OBJECTIVES

- Increase the frequency of environmental flows in the permanent and temporary lagoons in Martin Bend to provide habitat for native fauna and to promote the regeneration of wetland and floodplain vegetation.
- Reduce surface water salinity levels via a coordinated approach to management, including flushing salt from the wetland and investigating options to reduce input of saline groundwater.
- Manage stormwater drainage to limit the negative impact it has on the ecosystem, while investigating options to utilise the stormwater for wetland management.
- Plan and implement an ongoing revegetation program in Martin Bend involving local community
- Control the abundance of noxious weeds and other pest plants.
- Control the abundance of pest animals in Martin Bend, particularly rabbits and introduced species of fish.
- Maintain a vibrant community group with the capacity to undertake wetland management and a wetland monitoring program.
- Improve the existing recreational facilities in Martin Bend, including maintenance of the walking trail and development of additional visitor facilities, and identify and conserve the sites of significant cultural and/or social heritage.
- Improve community awareness and education about wetland management by promoting use of the wetland for recreation, keeping local community informed and involving local schools.
- Formalise ongoing management arrangements in Martin Bend with key stakeholders,

MARTIN BEND MANAGEMENT ACHIEVEMENTS

1970s	▪ Development of the Berri Marina and the Stormwater and Drainage Disposal Basin
	▪ Development of walking trail by the Berri Lions Club
1997	▪ EPA Frogwatch began monitoring at Martin Bend
1998	▪ Martin Bend Steering Committee (community group) formed June 1998
	▪ Initial Martin Bend Management Plan was completed by ID&A (South Australia) Pty Ltd (December 1998).
2000/ 2001	▪ Natural Heritage Trust (NHT) funding received (~$20,000) to undertake on-ground works in Martin Bend for wetland management
	▪ Works undertaken to decrease the sill levels of the downstream and upstream inlets in Martin Bend (i.e. spillway constructed over walking trail, additional culverts installed under road)
	▪ Installation of regulator on the downstream inlet of the permanent lagoon
2003	▪ Two piezometers installed to monitor groundwater levels and salinity during February 2003
	▪ Waterwatch involved in monitoring water quality and macroinvertebrates during May 2003
	▪ Baseline Survey of physical and ecological features of Martin Bend undertaken 2003/2004
2004	▪ Four photo-points installed around the permanent and temporary lagoons March 2004
2005	▪ River Murray weir manipulation during September 2005 - resulted in increased flows into Martin Bend, inundating the permanent and temporary lagoons
	▪ Martin Bend selected as a site for the River Red Gum Rescue project coordinated by DWLBC. Approximately 100 ML of water was pumped into the wetland between 26 October and 2 November 2005
	▪ Berri Lions Club and students from Glossop High School involved in revegetation project near the stormwater ponds
	▪ Community meeting held to discuss Wetland Management Plan (October 2005)
2006	▪ Community meeting held to discuss Wetland Management Plan (1st February 2006)
	▪ Martin Bend included as site for the BBLAP Wetland Tour (9th February 2006)
	▪ Elevation survey of Martin Bend undertaken by consultants Alexander & Symonds Pty Ltd
	▪ Martin Bend Wetland Group (community group) established, which undertake wetland monitoring in Martin Bend

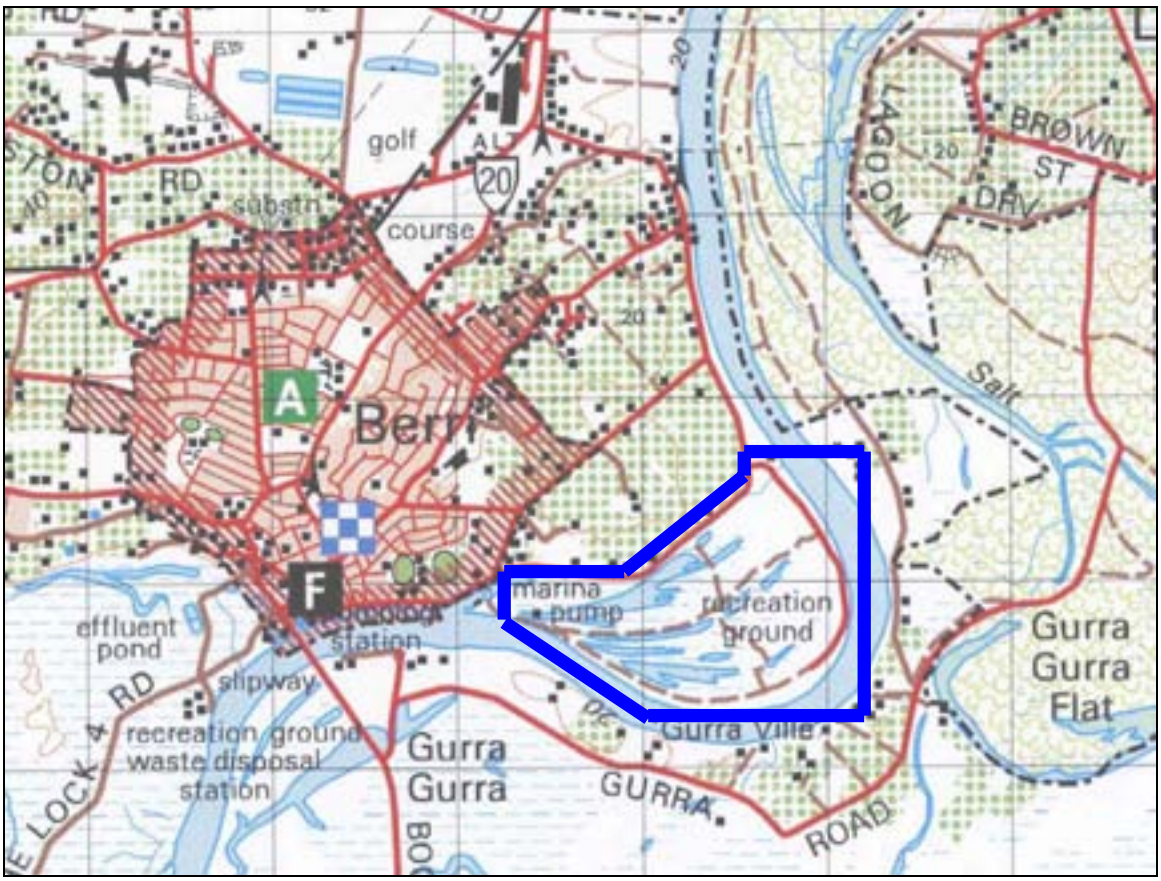
SITE DESCRIPTION

LOCATION

Martin Bend is located adjacent to the River Murray approximately 2 km east of Berri (Map 1).

The wetland is at a river distance of 528 km upstream from the River Murray mouth, and 12 km upstream of Lock/Weir 4. Martin Bend can be found on the 1:50,000 map sheet 'Loxton - 7029-3' at 464587 E, 6205636 N (AMG zone 54).

Martin Bend is described in the *Wetlands Atlas of the South Australian Murray Valley* (Jensen *et al*. 1996) under atlas number S0206.



Map 1. Location of Martin Bend (area within blue line), near Berri, South Australia

PHYSICAL FEATURES

Geomorphology

Martin Bend is a wetland-floodplain complex in a natural low depression adjacent to the River Murray. The complex includes a number of parallel wetlands between the river and high land, described by Pressey (1986) as 'Scroll Swales'.

Martin Bend covers an area of approximately 145 ha, which includes permanent and temporary wetlands and floodplain habitat. Wetland habitat includes five separate lagoons, these include: one permanent lagoon, three temporary lagoons, and a stormwater and drainage disposal basin.

Soils

Soils in Martin Bend have not been comprehensively mapped. Field observations identified the soils in the wetland were dark, heavy clays. Soils on the floodplain at higher elevation had a higher sand content (H. Robertson pers. obs. 2005). Soil logs produced during the drilling of wells for groundwater piezometers noted the soil profile (maximum depth 5m) consisted mostly of sand, with varying amounts of clay (SKM 2004).

Soil nutrients, salinity and pH were analysed from 4 sites near the stormwater basin in Martin Bend in March 2006 (D. Mathews pers. comm. 2006). A summary of the results is presented in Appendix 1.

A study by CSIRO examining River Murray wetlands noted accumulation of sulfidic materials in wetland soils are impacting on the ecological and aesthetic values of a number of wetlands in the region. Future managers should beware of the potential for sulfidic compounds to develop in Martin Bend, and the risk presented by the development of noxious odours and acid sulphate soils (Lamontagne *et al*. 2004). Current research on sulphidic soils at Loveday Basin may provide results that outline the advantages and disadvantages of different wetland management options (B. Turner pers. comm. 2006).

There has also been recent research into the microalgal (diatom) community found in the top 35cm of the soil profile in Martin Bend (J. Fluin pers. comm. 2006). This research showed clear evidence of acidification (decrease in pH) in Martin Bend over the past few years (see 'Water Quality' for details).

Climate

The Riverland region of South Australia experiences hot dry summers and cool winters. The climate is described as warm (persistently dry). The average maximum daily temperature for Berri is 23 ˚C, ranging between 31˚C in January and 15˚C in July (Table 1). The average annual rainfall is 260 mm with most falling during the winter months. Evaporation rates are highest during the warmer summer months. In no months does rainfall exceed evaporation (Bureau of Meteorology 2005).

Table 1. Monthly average temperature, rainfall and evaporation recorded at Berri.

	Month												Annual Avg.
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	
Temp. (max)	31.1	30.2	28.1	22.6	18.9	15.8	15.5	17.2	20.8	23.5	26.9	29.7	23.3
Temp. (min)	15.2	15.0	13.4	10.1	7.9	6.2	5.3	5.9	7.7	10.0	12.1	14.2	10.2
Rainfall (mm)	16.5	22.1	11.4	16.5	27.9	26.0	24.3	27.1	26.8	24.3	19.9	19.2	262
Evap. (mm)	324	288	260	143	97	56	52	95	134	184	271	329	2233

Source: Bureau of Meteorology (2005).

HISTORICAL & CURRENT WATER FLOWS

Wetland habitat in Martin Bend includes five different lagoons (Map 2), these are:

- a permanent lagoon (in recent years this permanent lagoon has been disconnected from the River Murray)
- three temporary lagoons
- a stormwater and drainage disposal basin

The five lagoons all have different water regimes. There are a number of inlet channels, which connect the lagoons to the River Murray (Map 3). The main inlet is situated to the southwest of Martin Bend, which use to form a permanent connection to the River Murray at pool level (inlet has recently been disconnected due to increase in silt and vegetation).

Temporary inlets (above pool level) are only connected the River Murray during flood events (e.g. > 50,000 ML/day flow).

Historical flows

Prior to the regulation of flows in the River Murray, and the development of irrigated agriculture, Martin Bend would have frequently been flooded. Flows into South Australia of >52,000 ML/day occurred in >75% of years prior to river regulation (MDBC 2005). However, the volume, rate, frequency and timing of flood events would have varied considerably depending on the flows in the River Murray.

Martin Bend would also have been frequently dry, at times when the water level in the river dropped below the wetland.

Current flows

Since river regulation and the construction of locks and weirs along the River Murray, the water regime in Martin Bend has been altered. Under current conditions flows into South Australia of >52,000 ML/d now occur in <30% of years (MDBC 2005).

Following the construction of Weir and Lock 4 (in 1929) the permanent lagoon was connected with the River Murray at pool level (FSL 13.20 mAHD). When filled to pool level, the permanent lagoon had an inundated area of approximately 5 ha, and a maximum depth of 0.6 m.

In 2001, a regulator was installed on the downstream inlet to control water levels in the permanent lagoon. However, due to low flows in the River Murray (Figure 1) and the build-up of silt and vegetation in the inlet, the ‘permanent lagoon’ has been disconnected from the river, which has resulted in the wetland partially drying (H. Robertson pers. obs. 2006).

Since river regulation, the three temporary lagoons in Martin Bend (T1, T2 & T3) have been dry for prolonged periods (Map 2). During 2001, two pipes were installed in Martin Bend to increase the frequency of flood events in temporary lagoons T1 and T2. One pipe connects the permanent lagoon with T1, and another pipe connects T1 with T2 (Map 2).

A number of other pipes also facilitate flows in Martin Bend. Refer to ‘Water flow structures’ for details.

In the 1970s, the stormwater and drainage disposal basin was developed in Martin Bend. The disposal basin was created to provide a detention basin for stormwater and drainage water before it enters the River Murray (Ken Smith Technical Services 2002). The water level that is maintained in the stormwater and drainage basin is the same as the River Murray pool level. Altering the base water level

in the basin (i.e. increasing water level to increase area of wetland habitat) may also increase the groundwater gradient towards to the River Murray (this has to be considered before undertaking any future on-ground works).

Temporary Lagoon T3 receives some water flows from stormwater and drainage. Water flows are facilitated by a channel between the disposal basin and T3, which was constructed in 2001 (Map 2). This channel allows stormwater to back fill into the lagoon during periods of high rainfall.

Groundwater seepage also provides a source of water input to the wetlands, which has been exacerbated by significant increases in regional groundwater levels following the development of irrigated agriculture. Temporary Lagoon T3 appears to be most affected by groundwater seepage (H. Robertson pers. obs. 2006), since it is closest to the irrigated land (see 'Groundwater' section for further details).

In addition to the large-scale changes in river flows since river regulation, the recent drought in the Murray-Darling Basin has also affected the frequency of flood events. Figure 1 shows that between 1974 and 1996 there were frequent River Murray flood events at Martin Bend. However, over the last decade the frequency of flood events has declined significantly.

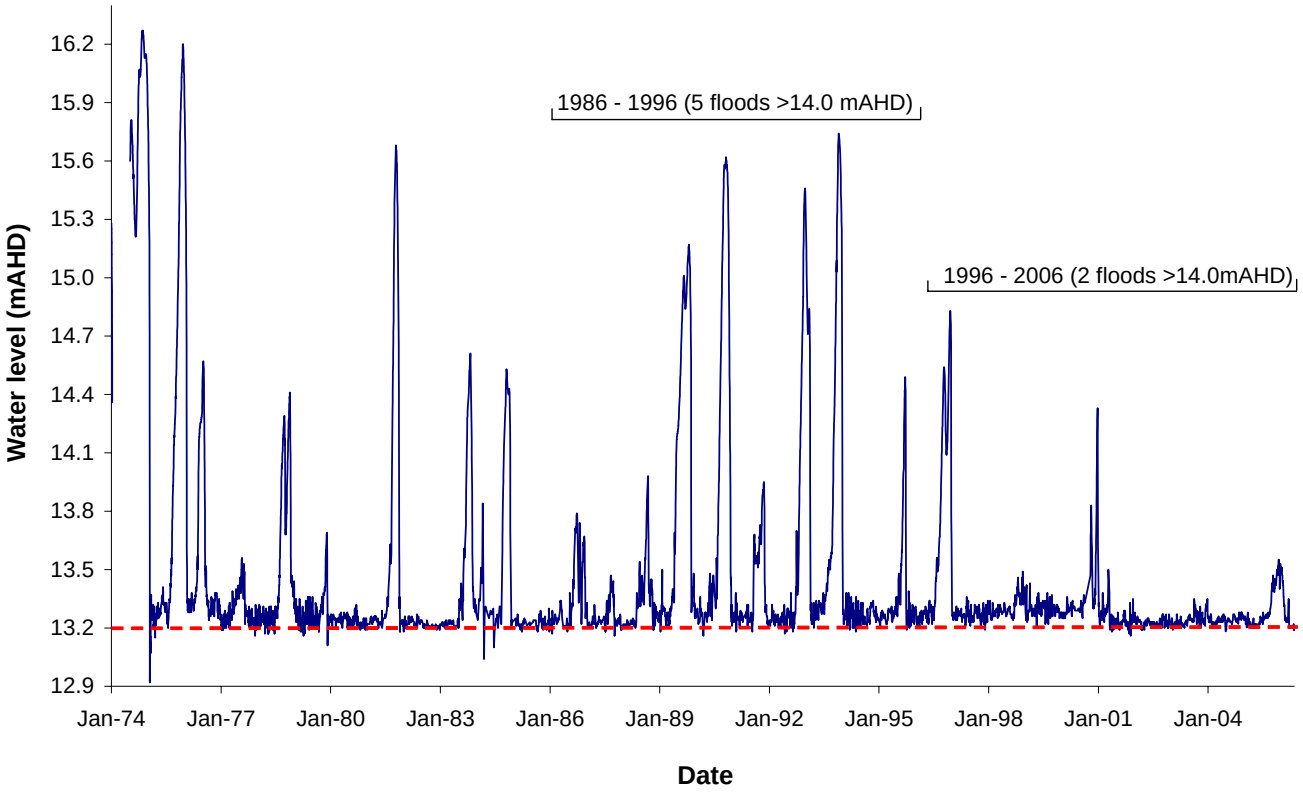
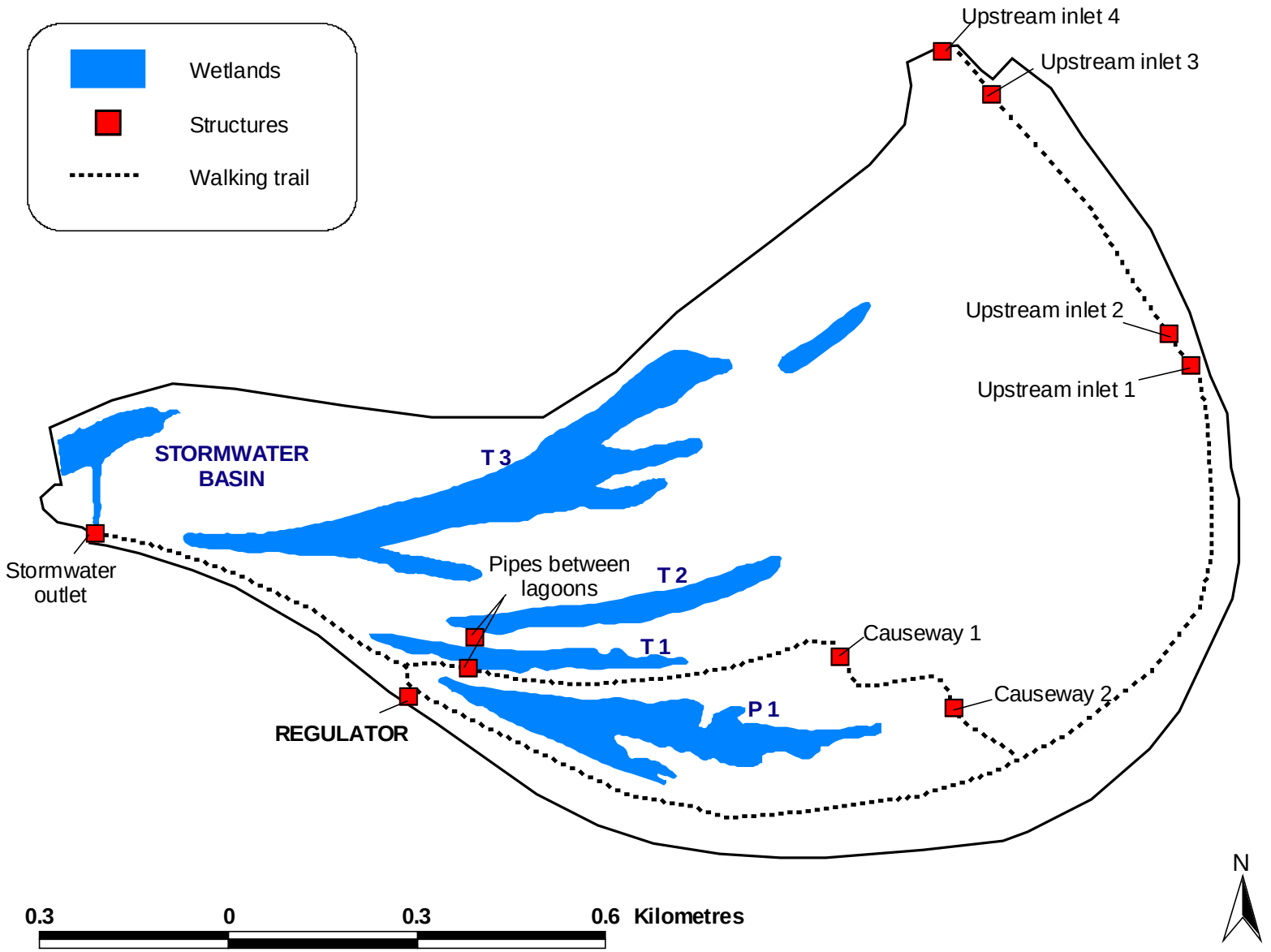
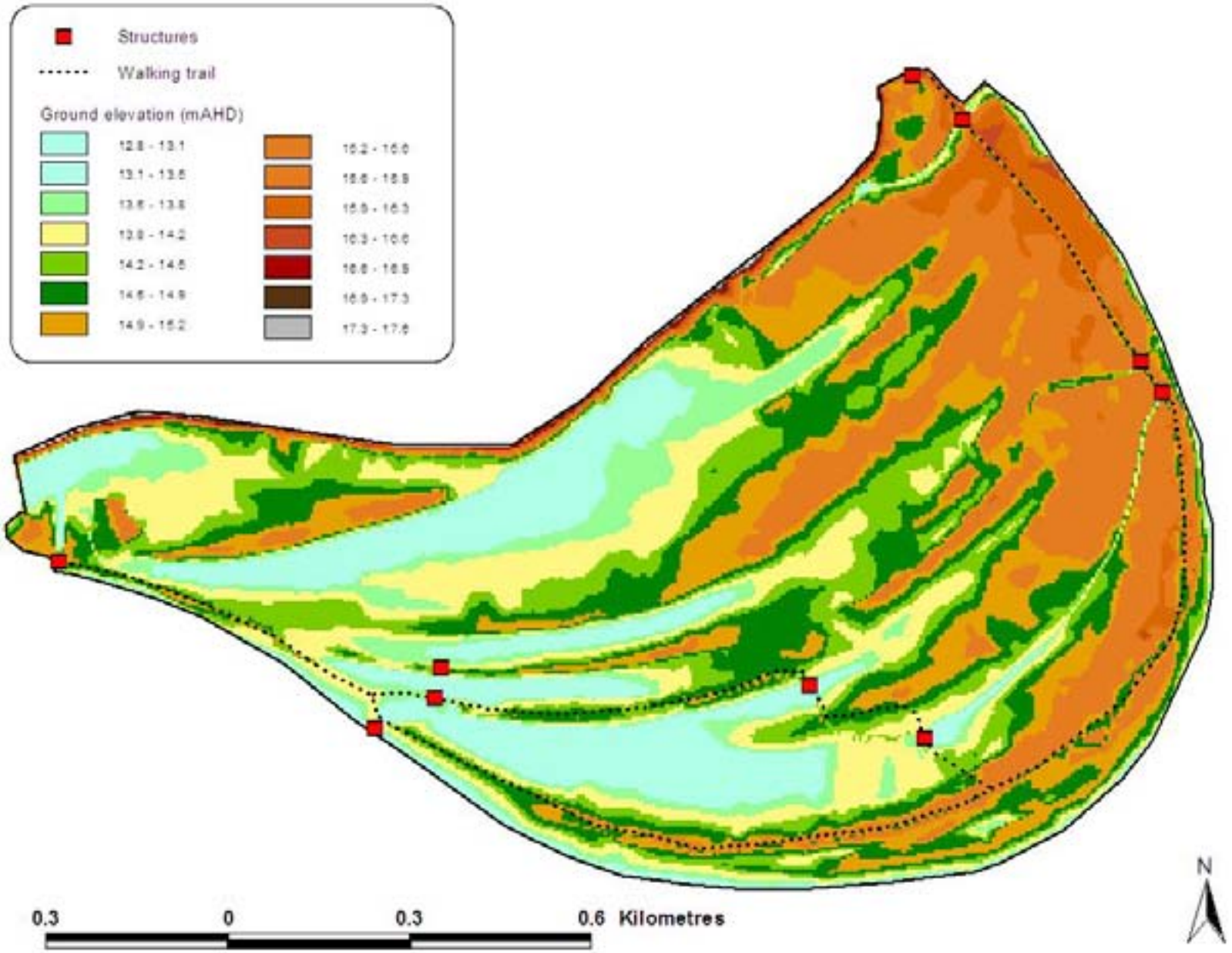


Figure 1: River Murray water level at Berri between 1974 and 2006 (Source: DWLBC 2006).

The permanent lagoon in Martin Bend has experienced a reduced flooding frequency over the last 5 years due to the low flows in the River Murray, and due to the build-up of silt and vegetation in the downstream inlet. Without works to decrease the sill level of the inlet channel (to mitigate the sedimentation), it is not possible to provide to inundate the permanent wetland at normal pool level (see 'Proposed works to structures & inlets' for management recommendations).



Map 2. Location of the five lagoons and flow management structures in Martin Bend. **Key**: Permanent lagoon (P1), Temporary lagoons (T1, T2 & T3).



Map 3. Digital elevation model of Martin Bend showing ground elevation (mAHD) of the floodplain and wetlands. ***Note****: River Murray pool level adjacent to Martin Bend is 13.2 mAHD*.

WATER FLOW STRUCTURES

Description of structures

Martin Bend contains one regulator and a number of unregulated structures (Map 2).

The regulator is located on downstream inlet approximately 20 m from the River Murray. The regulator consists of three 0.9 x 1.2 m box culverts with fish screens (Figure 2). The base (invert) of the regulator is 13.18 mAHD. The top (crest) of the regulator is 14.26 mAHD, which is also the maximum water level that can be managed in Martin Bend.

Water flow in the downstream inlet is partially blocked by vegetation (a high abundance of Cumbungi *Typha* spp. and Common Reed *Phragmites australis*) and by the build-up of silt in the inlet. Control of the abundance of plants and dredging (to remove silt) may be required to enable water to flow into Martin Bend. Control of the abundance of vegetation may also improve passage for aquatic fauna.

Figure 2. Photograph of regulator on the downstream inlet in Martin Bend.

The unregulated structures in Martin Bend include pipes between lagoons, pipes under vehicle tracks within the wetland, and pipes across upstream inlet channels (under the sealed road). There are no fish screens on the unregulated structures.

Photographs of some of the unregulated structures in Martin Bend are provided below (Figure 3).

The location, sill level and commence to flow level for each structure is listed in Table 2.

a) Three pipes under track at Causeway 1

b) Pipe between permanent and temporary lagoon

c) Causeway 2

d) Upstream inlet 3

Figure 3. Photographs of some of the unregulated structures in Martin Bend.

Table 2. Geographic coordinates, sill levels and commence to flow rates (River Murray) for the downstream and upstream inlets in Martin Bend.

Inlet	Location (AMG Zone 54)	Structure	Sill level * (mAHD)	Commence to flow
Downstream inlet	464766 E 6205567 N	0.9 x 1.2 m box culverts (3)	13.18	Flows at pool level
Pipe between P1 & T1	464859 E 6205606 N	0.76 m diameter pipe	13.33	30,000 ML/day
Pipe between T1 & T2	464868 E 6205652 N	0.76 m diameter pipe	13.75	>40,000 ML/day
Causeway 1 (P1)	465479 E 6205608 N	0.53 m diameter pipes (3)	13.88	-
Causeway 2 (P1)	465672 E 6205533 N	0.53 m diameter pipe	13.91	-
Upstream inlet 1	466062 E 6206109 N	0.9 m diameter pipe	13.08	Structure blocked**
Upstream inlet 2	466022 E 6206154 N	0.9 m diameter pipe	14.30	>50,000 ML/day
Upstream inlet 3	465707 E 6206589 N	0.9 m (2) + 0.53 m diameter pipes	14.32	>50,000 ML/day
Upstream inlet 4	465635 E 6206627 N	0.53 m diameter pipes (2)	15.08	>60,000 ML/day

* Normal Lock/Weir 2 pool level is 13.20 m AHD.
** Sill level of upstream inlet 1 is below pool level, however pipe appears to be blocked (H. Robertson pers. obs. 2006)

Proposed upgrades to structures & inlets

Downstream regulator

The base (invert) of the main regulator lies at an elevation of 13.18 mAHD, which is slightly higher than the elevation of the bed of the inlet. At pool level (13.20 mAHD), there is a poor connection between the permanent lagoon and the river.

Under current conditions, accumulation of silt and vegetation in the downstream inlet has blocked flow of water. Flooding in the wetland has also been less frequent due to prolonged period of low flows in the River Murray (Figure 1).

It is recommended to excavate (dredge) the inlet channel to allow water to flow into the wetlands. Although it is difficult to assess exactly how much silt and vegetation has accumulated, dredging the inlet to a level of 13.10-13.15 mAHD would increase the capacity for environmental flows (current level ~ 13.15-13.25 mAHD).

It is also recommended to investigate options to install a new regulation structure at a lower elevation (e.g. with invert 13.10-13.15 mAHD), to allow effective management of water levels in Martin Bend.

Pipes between permanent and temporary lagoons

The pipes between P1 and T1 and between T1 and T2 provide a mechanism for water to flow from P1 to the temporary wetlands when the water level in P1 is > 13.33 mAHD.

These pipes are unregulated (permanently open). This reduces the capacity to manage the water levels in one wetland at a time (e.g. increase depth of inundation in P1).

It is recommended to:

- install stop gate on end of pipe between P1 and T1
- install stop gate on end of pipe between T1 and T2

This would enable the water levels in P1 and T1 to be managed independently. The stop gates would also provide wetland managers with the ability to fill one wetland at a time (i.e. if there was limited water available).

Other unregulated structures

The function of the upstream inlet pipes near the Berri Water Ski Club also needs to be reviewed.

The small diameter of some of the pipes may restrict the total volume of water flowing into Martin Bend during flood events. Upstream inlet 1 (Map 2) may be partially blocked.

It is recommended to:

- review the function of all unregulated culverts and pipes in Martin Bend, with a view to replacing some of the structures.
- assess whether the pipe across Upstream Inlet 1 is blocked, and undertake maintenance if required.
- Investigate options to decrease the sill level of the upstream inlets (e.g. Upstream Inlet 1) to promote the downstream flow of water through Martin Bend.

WEIR MANIPULATION & PUMPING PROJECT (2005)

Between 20 September 2005 and 2 November 2005, Martin Bend received environmental flows. The environmental flows were the result of a weir manipulation in the River Murray, and due to the River Red Gum Rescue Project.

Stop logs were removed from regulator on the 20th September 2005 as river levels increased during the weir manipulation (Lock 4 pool level increased to > 13.5 mAHD). During this period the water level in the permanent lagoon increased by over 40 cm (Figure 4).

Martin Bend was then selected as a site for the River Red Gum Rescue project. Approximately 100 ML of water was pumped into the permanent (P1) and temporary lagoons (T1 and T2) between 26 October and 2 November 2005. This increased the water level by a further 60 cm (Figures 4 & 5).

Salinity levels decreased markedly during the weir manipulation and pumping project. The environmental flows also resulted in an increase in waterbird diversity and abundance, and supported the growth of charophytes (submerged aquatic plant).

If only the weir manipulation or the pumping had occurred in isolation, the duration of the flood event would have been much shorter, and the ecological benefits not as great.

For future flood events it is recommended to investigate options to prolong the duration of inundation (e.g. pump water into wetlands on more than one occasion over a 3-6 month period).

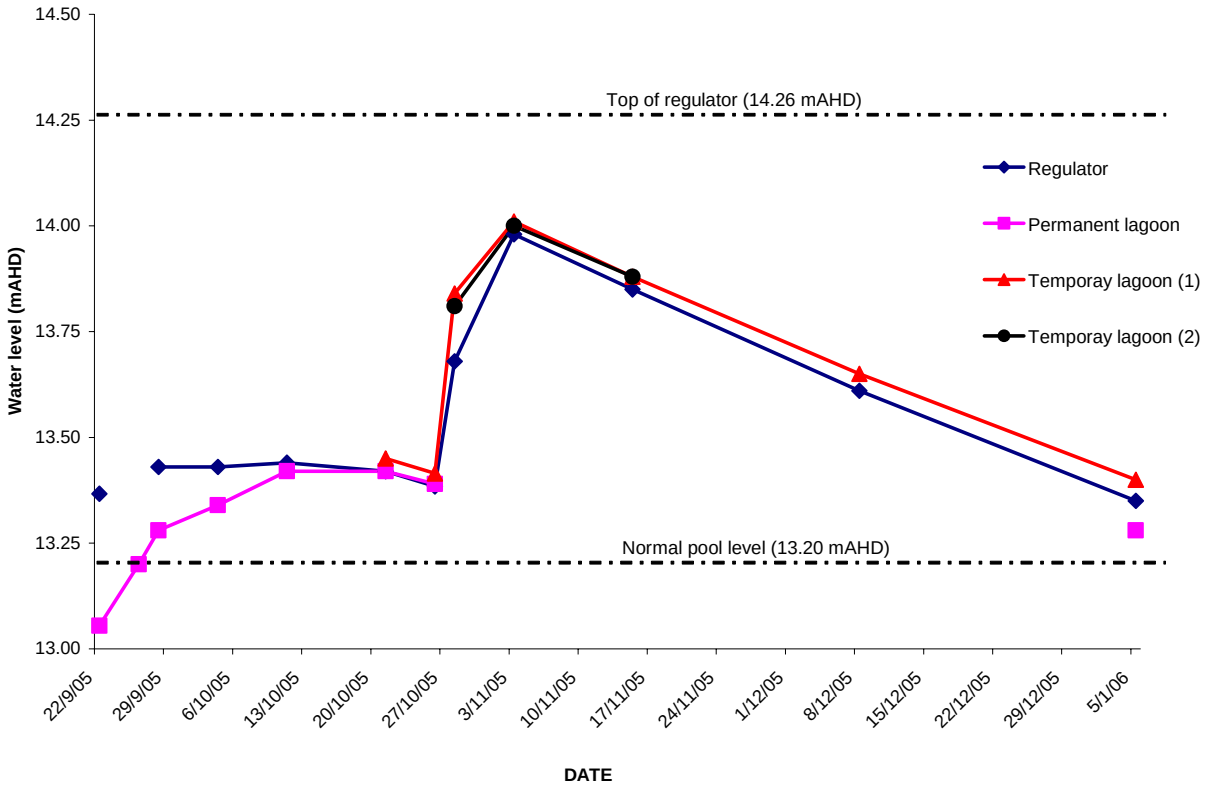


Figure 4. Water level fluctuation in permanent and temporary lagoons between September 2005 and January 2006.

Figure 5. Photographs of the increased water levels following the pumping project in Martin Bend.

FLOOD INUNDATION MODEL

The River Murray Flood Inundation Model (Overton *et al*. 1999) presents hypothetical scenarios of where water would flow in a wetland under different river flow rates. The output from the model can assist management decisions when assessing in-coming River flows, or with manipulating water flow using flow control structures.

The following diagrams show the extent of inundation in Martin Bend (Figure 6). Until River Murray flows are above 50,000 ML/day, there is little change in the area of the wetland inundated in Martin Bend. At 100,000 ML/day, the wetland and most of the surrounding floodplain is connected to the river channel.

However, the Flood Inundation Model does not capture the inundation of the upstream inlets in Martin Bend. This is due to the size of the channels and the scale of the computer model. Refer to Table 2 for the commence to flow rate for the downstream and upstream inlets in Martin Bend.

WETLAND VOLUME

Information on the surface area, maximum water depth, and volume of inundation are required to determine the environmental water requirements of Martin Bend.

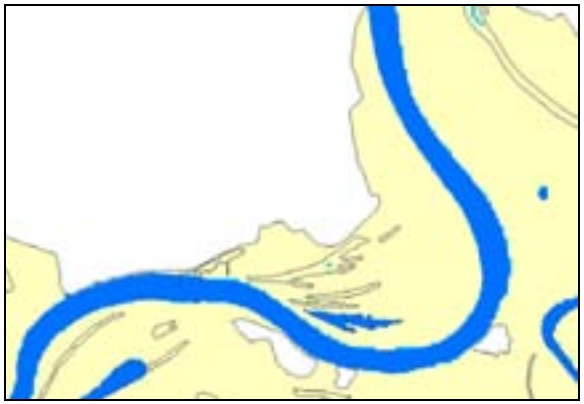
Table 3 lists the area, depth and volume of inundation for Martin Bend, based on a comprehensive elevation survey of Martin Bend undertaken during 2006, which was financially supported by DWLBC (Alexander & Symonds Pty Ltd 2006, refer Appendix 13).

Approximately 15 ML of water is required to fill the permanent lagoon to normal pool level (13.20 mAHD). Approximately 140 ML is required to inundate the permanent lagoon, T1 and T2 to a water level of 14.20mAHD.

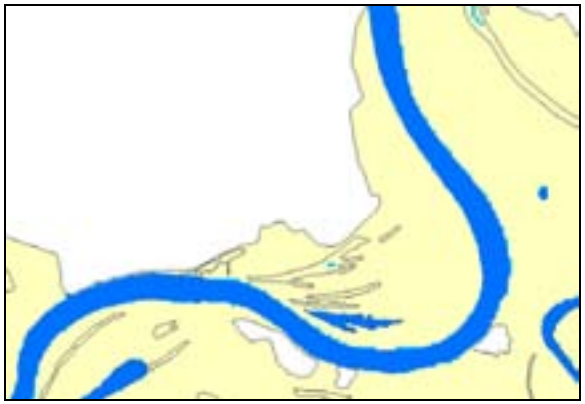
Table 3. Surface area, maximum depth and volume of inundation for different water levels in the permanent and temporary lagoons in Martin Bend.

Water Level (mAHD)	Permanent lagoon			Temporary lagoon 1			Temporary lagoon 2			TOTAL (P1, T1, T2)		
	Area (ha)	Depth (m)	Vol. (ML)	Area (ha)	Depth (m)	Vol. (ML)	Area (ha)	Depth (m)	Vol. (ML)	Area (ha)	Depth (m)	Vol. (ML)
13.00	3.5	0.34	5	-	-	-	-	-	-	3.5	-	5
13.20 (pool level)	5	0.54	15	-	-	-	-	-	-	5	-	15
13.40	6	0.74	20	1	0.40	2	-	-	-	7	-	22
13.60	7.5	0.94	25	1.5	0.60	5	-	-	-	9	-	30
13.80	9.5	1.14	55	2	0.80	8	2.5	0.60	7	14	-	70
14.00	11.5	1.34	75	2.5	1.00	13	3	0.80	12	17	-	100
14.20	15.5	1.54	115	3	1.20	15	4.5	1.00	20	23	-	140

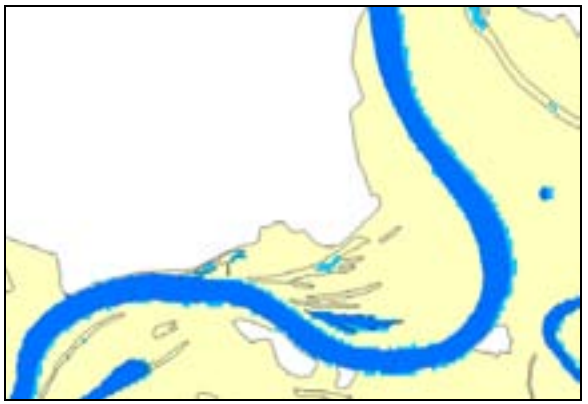
Notes:
- Surface area and volume estimates calculated within GIS (Arcview *3D* Analyst) based on data from the Martin Bend Elevation Survey (Alexander & Symonds Pty Ltd 2006).
- Minimum elevation of Permanent Lagoon approximately 12.66 mAHD (SKM 2004).
- Commence to flow level for Temporary Lagoon 1 is 13.33 mAHD
- Commence to flow level for Temporary Lagoon 2 is 13.75 mAHD



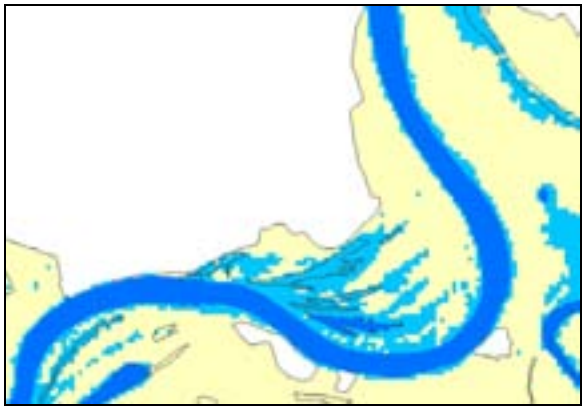
10,000 ML/day flow



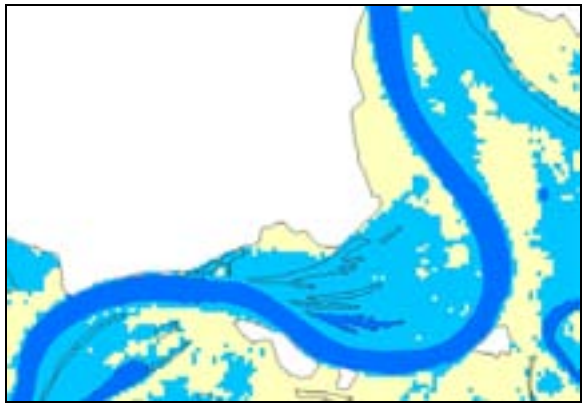
25,000 ML/day flow



50,000 ML/day flow



75,000 ML/day flow



100,000 ML/day flow

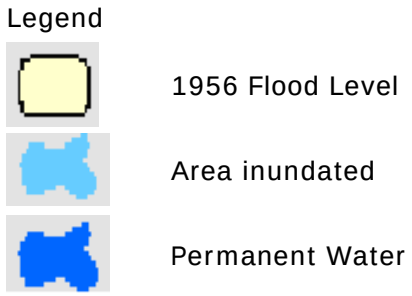


Figure 6. River Murray Flood Inundation Model for Martin Bend, showing area of wetland inundation under different flow rates.

GROUNDWATER

Groundwater has an impact on surface water hydrology, and soil and surface water salinity, in Martin Bend. Changes in land use in the region since European settlement including the development of irrigated agriculture and the clearing of deep-rooted native vegetation have altered the groundwater hydrology, which has resulted in the salinisation of Martin Bend.

Groundwater was studied as part the River Murray Wetlands Baseline Survey (SKM 2004) and as part of community wetland monitoring (B. Turner pers. comm. 2006). A description of groundwater hydrology and groundwater salinity is presented below.

Groundwater hydrology

The depth of the groundwater table in Martin Bend was recorded from 6 piezometers on four occasions between February and August 2004 during the Baseline Survey. The piezometers were located between the river and the permanent lagoon, and to the north of the permanent lagoon (SKM 2004).

Refer to Appendix 3 for the location of the piezometers in Martin Bend.

The groundwater table elevation ranged from 12.2 to 13.1 mAHD in February 2004, compared to the river pool level 13.2 mAHD (Figure 7). This indicated a groundwater flow gradient from the river into the wetland. It is also likely there is a groundwater flow gradient into the wetland from the irrigated land to the north of Martin Bend (SKM 2004).

Groundwater levels were often above the elevation of the wetland bed (permanent lagoon bed 12.66 mAHD), which indicates that groundwater seepage is likely to occur. The depth of the groundwater below ground level (bgl) ranged from 0.77 to 2.54 m bgl in February 2004 (SKM 2004). However, as no wells nested piezometers were sampled the assessment of vertical flow gradients was limited.

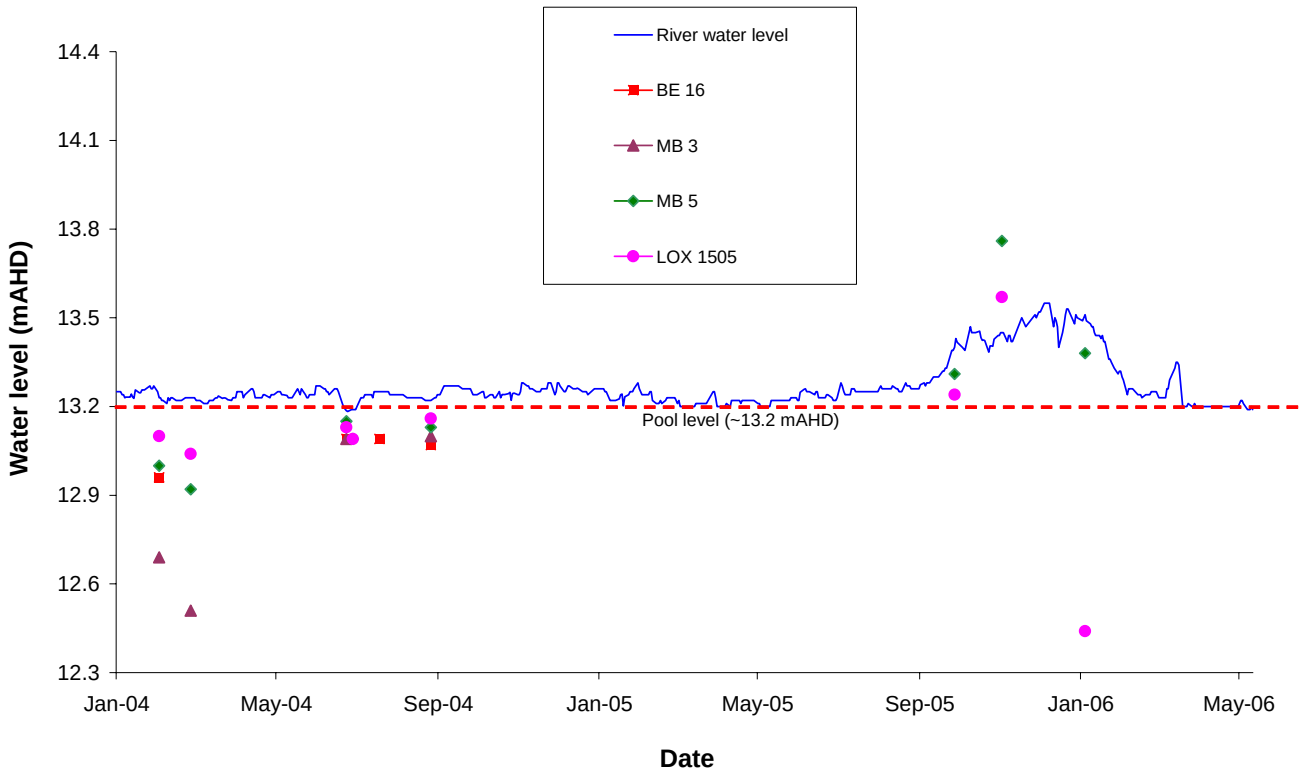


Figure 7: Groundwater table level (mAHD) from 4 piezometers in Martin Bend between 2004 and 2006. Change in the River Murray water level also shown relative to pool level (red line).

Groundwater was also monitored on three occasions between September 2005 and January 2006 by the SA MDB NRM Board and BBLAP, during the environmental flow event (Appendix 2). During this period the elevation of the groundwater table ranged from 12.44 to 13.76 mAHD.

Reducing the input of saline groundwater is a high priority to decrease the salinity levels in Martin Bend. It is recommended to inundate the wetlands in Martin Bend to decrease the input of groundwater (by hydrological pressure). A reduction in the upward pressure of groundwater may also facilitate the development of a freshwater lens below the surface of the wetland (Steggles and Tucker 2003).

Ongoing monitoring of the surface water-groundwater interactions is a high priority for wetland management. Installation of nested piezometers in the wetland bed is recommended to support the monitoring program (i.e. monitor presence/absence of freshwater lens).

Groundwater salinity

Groundwater salinity was recorded in four wells during the Baseline Survey. During February 2004, salinity levels ranged from 3,000 to 36,000 µS/cm (Figure 8). The freshest groundwater was to the north of the wetland, suggesting input of less saline irrigation drainage water (SKM 2004). Groundwater was more saline near the permanent lagoon (Appendix 2 & 3).

Groundwater salinity was also recorded on three occasions between September 2005 and January 2006 by the SA MDB NRM Board and BBLAP. Salinity levels ranged between 10,000 and 45,000 µS/cm (Appendix 2).Notably, surface water salinity in Martin Bend is often high (e.g. 80,000 µS/cm). This indicates the input of saline groundwater and subsequent evapoconcentration of salts (SKM 2004).

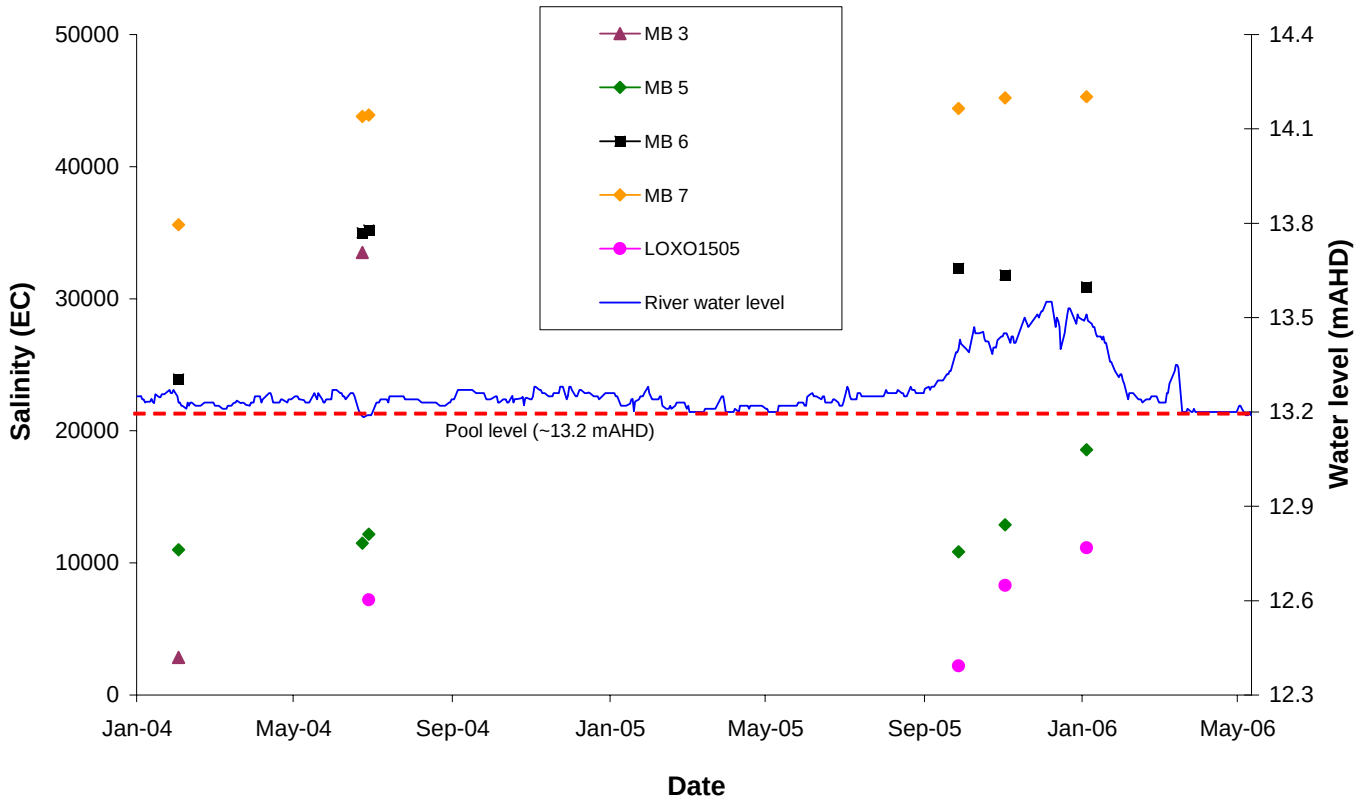


Figure 8: Groundwater salinity levels from 5 piezometers in Martin Bend between 2004 and 2006. Change in the River Murray water level also shown relative to pool level (red line).

Salinity or Electrical Conductivity (EC)?

Electrical conductivity or EC is a measurement used to *estimate* the concentration of salt (or salinity). EC is frequently used in wetland monitoring in Australia.

EC is usually measured in µS/cm (micro Siemens/cm).

A measurement of 5,000 µS/cm = 5,000 EC

The EC of seawater is approximately 55,000 EC. The EC of the River Murray is approximately 300 EC.

WATER QUALITY

Surface water quality was monitored on two occasions during the Baseline Survey, November 2003 and June 2004. Water quality was also monitored during July 2005 and September 2005 by the SA MDB NRM Board and BBLAP.

Table 4 lists the water quality results for Martin Bend. Future water quality monitoring is recommended to focus on understanding the variation in water quality over different seasons and with fluctuating water levels.

Table 4. Surface water quality in Martin Bend between 2003 and 2005.

Water quality parameter		**Date**			
		15 Nov. 2003 * (4 sites)	24 June 2004 * (4 sites)	1 July 2004 ** (3 sites)	28 Sept. 2005 ** (3 sites)
Salinity (EC in µS/cm @ 25°C)	*Min.*	7270	42000	42500	7560
	Max.	81100	80500	53500	26600
	Mean	47643	55000	46633	16453
Dissolved Oxygen (mg/L)	*Min.*	3.6	6.6	2.2	-
	Max.	9.4	15.1	14	-
	Mean	7.9	12.1	5.8	-
pH	*Min.*	7.68	6.22	5.55	-
	Max.	9.42	6.92	5.95	-
	Mean	8.25	6.58	5.75	-
Turbidity (NTU)	*Min.*	100	30	-	30
	Max.	550	210	-	30
	Mean	243	104	-	30
Temperature (°C)	*Min.*	19.4	15.5	11.2	20.8
	Max.	26.4	16.2	11.3	23
	Mean	23.1	15.8	11.3	21.8

Source:
* River Murray Wetlands Baseline Survey (SKM 2004)
** SA MDB NRM Board (Berri) monitoring data (B. Turner pers. comm. 2006)

Salinity (Electrical conductivity)

Surface water salinity levels ranging from 7,270 µS/cm to in-excess of 80,000 µS/cm (EC) were recorded during the Baseline Survey and community monitoring (Table 4). These salinity levels are moderate-extremely high, and considerably greater than the trigger levels set by ANZECC (2000) for water quality in South Central Australian freshwater lakes, reservoirs and wetlands (300-1,000 µS/cm).

High salinity levels are a result of the input of saline groundwater and the reduced frequency of flood events (which would normally flush salt) (SKM 2004).

Surface water salinity was also recorded on 12 occasions between September 2005 and January 2006 during the weir manipulation and pumping project (H. Robertson pers. obs. 2005-06). Figure 9 shows the change in salinity levels within the permanent lagoon during this period.

Increased water levels between September and November 2005 (water depth increased by 1.0 m) resulted in a significant decrease in salinity. Before the inflow of water, salinity levels were recorded above 30,000 µS/cm. Following the weir manipulation the salinity dropped to 6,000 µS/cm. However, as the surface water mixed and salt was released from the soil salinity levels quickly increased back to 12,000 µS/cm. Therefore, the effect of the weir manipulation on reducing salinity appeared to be short-lived (Figure 9).

Pumping of 100 ML of water for the River Red Gum Rescue Project also decreased surface water salinity. After pumping stopped on 2 November 2005, salinity levels dropped below 4,000 µS/cm (some sites below 1,000 µS/cm).

Between November 2005 and January 2006 salinity levels steadily increased as the water evaporated.

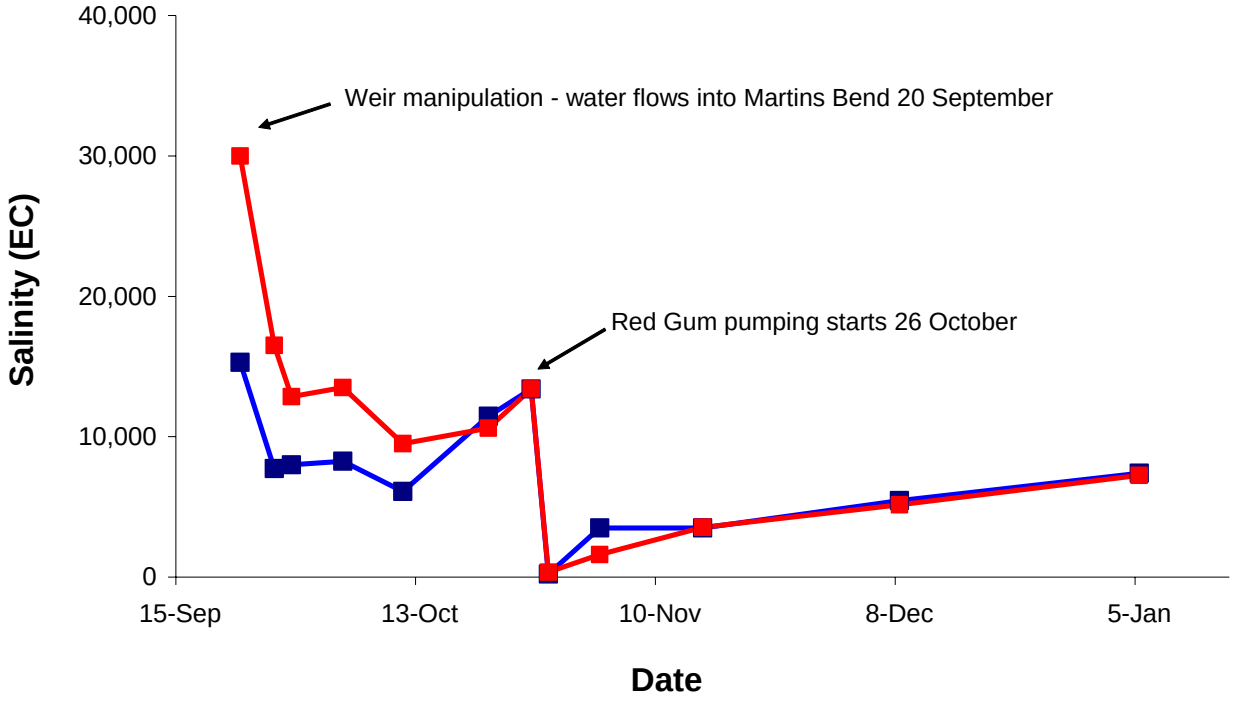


Figure 9. Surface water salinity levels at two sites in Martin Bend (permanent lagoon) between September 2005 and January 2006.

Salinity management

The impact of salinity on water quality will be a key factor in deciding how to manage the water regime in Martin Bend.

High salinity levels occur when the water level is decreasing and salts accumulate through evaporation. Lower salinity levels occur when the water level is increasing and salts are diluted. When the wetland is drying, there is also a reduction in hydrological pressure, and a greater potential for saline groundwater seepage to affect the system (Steggles and Tucker 2003).

The lack of flushing flows through the wetland, combined with saline groundwater reaching the surface of the wetland, has led to high surface water salinity levels.

Wetland rehabilitation may require significant investment in infrastructure to decrease salinity levels. This might include pumping water into the wetland on a more regular basis in the absence of natural flood events, and allowing water to flow out of the wetland after weir manipulations of pumping events.

Potential salinity impacts to the River Murray resulting from different management actions are also an important consideration (refer 'Flood Events'). However, salinity impacts to the River Murray had not been assessed at Martin Bend due to no suitable method being in existence (as of April 2006).

Dissolved oxygen

Dissolved oxygen concentrations ranging from 3.6 to 15.1 mg/L were recorded during the Baseline Survey. Since the wetland was shallow, the high dissolved oxygen levels were probably caused by wind-induced mixing of surface water and the abundant brown-coloured algae (SKM 2004).

Low levels of dissolved oxygen (e.g. < 4 mg/L) can be harmful or kill aquatic organisms, including freshwater fish.

pH

Moderate to high alkaline pH levels ranging from 6.2 to 9.4 were recorded in Martin Bend during the Baseline Survey. However, pH was generally within trigger levels defined by ANZECC (2000) for lowland rivers in south central Australia (maximum pH 9).

There has also been recent research into the microalgal (diatom) community found in the top 35cm of the soil profile in Martin Bend (J. Fluin pers. comm. 2006). This research showed clear evidence of acidification (decrease in pH) in Martin Bend over the past few years (Appendix 4). Specifically:

- In the older sediments (40-20cm below ground surface), the species and abundance of diatoms that were present showed that there used to be a strong connection between the river and the permanent lagoon.
- Recent sediments (20cm to surface) show clear evidence of acidification.
- There is a dramatic change in diatom assemblages from alkaline, planktonic taxa (indicative of river connection) to acidic, benthic taxa. These acidic diatoms (mostly *Pinnularia* spp.) have a pH optima < 4.5.
- The absence of riverine taxa during this acidic phase suggests low river connectivity.

Notably, pH levels can also impact on sulphur reactions in wetland soils (Lamontagne *et al*. 2004). Given the threat of sulphidic compounds in wetlands such as Martin Bend, pH monitoring is important.

Turbidity

Turbidity is an estimate of the 'cloudiness' or 'muddiness' of the water, with higher turbidity levels relating to more 'turbid' water.

Turbidity levels ranging from 30 NTU to 550 NTU were recorded in Martin Bend during the Baseline Survey. The maximum turbidity levels exceeded the trigger levels set by ANZECC (2000) for lakes, reservoirs and wetlands in south central Australia (1-100 NTU). As for dissolved oxygen, the high turbidity may have been influenced by wind conditions (SKM 2004).

Continued high levels of turbidity can suppress the growth of aquatic plants by limiting penetration of underwater light. This may impact on the growth of the submerged aquatic plant (*charophyte*) recorded in the permanent lagoon in Martin Bend (H. Robertson pers. obs. 2006). High levels of suspended solids (a factor causing turbidity) can also impact on algae, biofilms and on aquatic fauna.

Nutrients

The concentration of nutrients in the permanent and temporary lagoons in Martin Bend has not been previously investigated. Nutrient concentrations in the temporary lagoon to the north of Martin Bend (T3) may be high due to the inflow of stormwater and drainage water.

Continued high levels of nutrients (e.g. nitrogen, phosphorus) can affect water quality and alter the wetland ecosystem (e.g. lead to algal blooms). It is recommended to include nutrients as a water quality monitoring parameter in future surveys.

Nutrient concentrations in the stormwater and drainage basin have been recorded on one occasion (March 2006). Nutrient concentrations were: Nitrate (NO_3) 59.7 mg/l; Ammonium (NH_4) 0.28 mg/l; Phosphorus 0.44 mg/l (D. Mathews pers. comm. 2006). Further monitoring of nutrients in the stormwater ponds is necessary to see if these measurements remain consistent.

In future, the wetlands in Martin Bend may be used to filter nutrients from the stormwater and drainage ponds. Decrease in nutrient levels would have a positive impact on water quality in the River Murray. Refer to 'Stormwater & Drainage Disposal Basin: Proposed Works' for further details.

Temporary lagoon (T2) under dry conditions (April 06).

Permanent lagoon (P1) under dry conditions (April 06)

ECOLOGICAL FEATURES

The ecological features of Martin Bend were recorded as part of the Baseline Survey using the monitoring methods outlined in *Your Wetland: Monitoring Manual* (Tucker 2004). This included information on the vegetation, fish, birds, frogs and macroinvertebrates.

Vegetation

Ten different vegetation communities were identified in Martin Bend during the Baseline Survey, specifically:

- River Red Gum (*Eucalyptus camaldulensis*)/ River Cooba (*Acacia stenophylla*) open forest
- Black Box (*Eucalyptus largiflorens*)/ River Cooba (*A. stenophylla*) woodland
- Black Box (*E. largiflorens*)/ Dryland Tea-tree (*Melaleuca lanceolata*) woodland
- Black Box (*E. largiflorens*) / Dryland Tea-tree (*M. lanceolata*) open forest
- Black Box (*E. largiflorens*) open forest
- Black Box (*E. largiflorens*) woodland
- Samphire (*Halosarcia* spp.) shrubland
- Saltbush (*Atriplex* spp.) shrubland
- Lignum (*Muehlenbeckia florulenta*) shrubland
- Common Reed (*Phragmites australis*) sedgeland

A number of smaller vegetation associations were also identified in the Baseline Survey. Refer to Appendix 5 for a map of the distribution of the vegetation communities and vegetation associations in Martin Bend. More detailed plant surveys using quadrats were undertaken in four of the vegetation associations. Refer to Appendix 6 for a list of the species recorded during the plant surveys.

Figure 10 provides photographs of some of the vegetation communities in Martin Bend.

Floodplain vegetation in Martin Bend, which surrounds the permanent and temporary wetlands, is dominated by tree and shrub species including Black Box (*Eucalyptus largiflorens*), River Red Gum (*Eucalyptus camaldulensis*), River Cooba (*Acacia stenophylla*), Dryland Tea-tree (*Melaleuca lanceolata*) Lignum (*Muehlenbeckia florulenta*), Samphire (*Halosarcia* spp.) and Saltbush (*Atriplex* spp.).

River Saltbush (*Atriplex rhagodioides*) shrubland to the east of the floodplain was considered the most significant vegetation community, which should be protected from disturbance (SKM 2004).

The dominance of Samphire (*Halosarcia* spp.) in the temporary wetlands suggests high soil salinity in these areas (Cunningham *et al*. 1992).

The condition (health) of River Red Gums on the floodplain generally declines away from the river edge, with trees in good health adjacent to the river. There are some dead River Red Gums in the permanent lagoon, which have died due to permanent inundation. A number of young River Red Gums occur on the fringes of the permanent wetland. These trees are likely to have established following previous flood events (e.g. 1990-1993), but are now suffering the affects of a prolonged period of drought. The health of Black Box is generally better than the River Red Gums in Martin Bend.

Wetland vegetation in the downstream inlet and fringing the permanent lagoon is dominated by emergent macrophytes, particularly Common Reed (*Phragmites australis*) and Cumbungi (*Typha* spp.).

High abundance of Common Reed around edge of the permanent lagoon is a threat to the aesthetic and ecological values of the wetland, and may need to be controlled in future. The high abundance of Cumbungi and Common Reed in the downstream inlet will also need to be controlled to allow water to flow between the River Murray and the permanent lagoon.

Please note: It is important that native flora and fauna surveys are undertaken prior to any pest plant control actions, to ensure the actions are not likely to impact on the ecosystem.

Common Reed (*P. australis*) and River Red Gum (*E. camaldulensis*) surrounding permanent lagoon.

Common Reed (*P. australis*) and River Red Gum (*E. camaldulensis*) in permanent lagoon.

Black Box (*E. largiflorens*) and Lignum (*M. florulenta*) surrounding temporary lagoon (T1).

Samphire (*Halosarcia* spp.), Black Box (*E. largiflorens*) and Lignum (*M. florulenta*) in temporary lagoon (T2).

Figure 10. Photographs of vegetation communities in Martin Bend (Photos: H. Robertson, 2005).

Few other aquatic plants were recorded in Martin Bend during the Baseline Survey. However, the increased flow of water into Martin Bend between September 2005 and January 2006 coincided with the establishment of Water Milfoil (*Myriophyllum* sp.), Water Primrose (*Ludwiga peploides* ssp. *montevidensis*), the floating fern Azolla (*Azolla* sp.), Duckweed (*Lemna* sp.) and Water Couch (*Paspalum distichum*) in the downstream inlet.

In January 2006 (after the increased water flow) large patches of a charophyte (a submerged aquatic plant) was observed in the permanent lagoon (H. Robertson pers. obs. 2006). The floating mats of *charophyte* were being grazed by swans. As well as providing a food source, charophytes help to stabilize the sediment and keep water clear, and provide habitat for macroinvertebrates (e.g. insects and crustaceans) (Casanova 2003). Some species of charophyte can be tolerant of high salinity.

Changes in the water regimes in the temporary wetlands should promote the establishment of more native wetland plants (SKM 2004). After the pumping project few Cumbungi (*Typha* sp.) seedlings were observed as having germinated in the temporary wetlands (T1) (H. Robertson pers. obs. 2005). However, as the water level decreased quickly these plants did not establish.

No plant species of conservation significance have been recorded in Martin Bend.

A number of pest plants have been recorded in Martin Bend, which may need to be controlled. Introduced pest plants observed in Martin Bend includes Willow (*Salix* sp.), Noogoora Burr (*Xanthium occidentale*), Golden Dodder (*Cuscuta campestris*), Wild Oats (*Avena* sp.), African Boxthorn (*Lycium ferocissimum*) and Common Sow-thistle (*Sonchus oleraceus*). Many of these introduced species are classified as terrestrial plants and would not tolerate inundation if a flood event occurred. The willows, which occur along the banks of the River Murray, do not currently present a significant ecological threat.

Noogoora Burr germinated on the fringes of the wetland after the increased water flows (H. Robertson pers. obs. 2006). Noogoora Burr is a potential host plant for Golden Dodder, and both species should be actively controlled in consultation with the SA MDB NRM Board. Notably, Golden Dodder was observed on some Noogoora Burr plants during February 2006, these plants were subsequently sprayed with herbicide (B. Turner pers. comm. 2006).

Vegetation management

Management of surface water and groundwater salinity, and management of the wetting and drying cycle, are important for the rehabilitation of native vegetation in Martin Bend. A decrease in soil and surface water salinity will promote the establishment of salt-intolerant plant species. The reestablishment of a wetting and drying regime closer to natural conditions will increase the duration of suitable growth conditions for wetland plants, and create more diverse habitat for fauna.

Ongoing monitoring of vegetation condition, including tree health surveys and fine-scale vegetation surveys is important to observe the response of wetland vegetation to wetting and drying regimes.

Appendix 7 provides examples of some of the photopoints used to monitor vegetation in Martin Bend.

Fauna

Refer to Appendix 8 for a list of fauna species recorded in Martin Bend.

Birds

More than 50 bird species have been recorded in Martin Bend from the Baseline Survey and from other surveys, including a number of significant species (Appendix 8).

Bird surveys were conducted at two sites during the Baseline Survey (2003/2004). These sites were areas of shallow water dominated by reeds, and included both wet and dry mud. A total of 10 species of water birds were observed in the wetland (125 individuals). Red-kneed Dotterel (*Erythrogonys cinctus*) and Black-fronted Dotteral (*Elseyornis melanops*) were the most abundant.

During summer of 2004 the wetland had largely dried out and there were fewer water birds present (SKM 2004). This indicates the importance of available water in both attracting and maintaining a diverse waterbird population.

Waterbird diversity and abundance increased significantly between September 2005 and January 2006 after the increased flow of water into Martin Bend. An additional 14 species of waterbirds were observed, including a number of species of cormorants, Great Egret (*Ardea alba*), White-faced Heron (*Egretta novaehollandiae*), Yellow-billed Spoonbill (*Platalea flavipes*), Australian Pelican (*Pelecanus conspicillatus*), Darter (*Anhinga melaongaster*) and Black Swans (*Cygnus atratus*). A pair of Black Swans with cygnets was observed in January 2006 (H. Robertson pers. obs. 2006).

Martin Bend provides habitat for at least one significant bird species. Ballion's Crake (*Porzana pusilla*), which is 'rare' in South Australia, was recorded in spring 2003. A number of migratory bird species

have also been observed in Martin Bend, which are listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Appendix 8).

Future bird surveys should be conducted during the spring months so as to be able to record signs of breeding and also during summer to record important refuge habitats.

Fish

A single fish survey was undertaken during the Baseline Survey (November 2003). No fish species were recorded during the survey. The absence of fish was due to the lack of water in the wetland. The water that was present was suspected to be groundwater, and the very high salinity of the water (maximum 80,000 EC) was above the tolerance of native freshwater fish (SKM 2004).

Following the increase in water levels during the environmental flows a number of Carp (*Cyprinus carpio*) were observed in the permanent lagoon and in the downstream inlet (H. Robertson pers. obs. 2005). Although no monitoring was undertaken, other species of introduced and native fish were also likely to be present, due to the increased water levels and decreased salinity. Although there are fish (Carp) screens on the regulator, these only restrict the movement of adult Carp.

Fish may be a useful indicator to monitor the condition of the wetland over time. The presence of fish may indicate improving habitats and reduced salinity levels.

Future fish monitoring should be carried out during spring and autumn. Surveys should also be repeated when the wetland is connected to the river to show which species are using Martin Bend when it is filled to pool level.

Frogs

Frogs surveys were undertaken as a part of the Baseline Survey in February, March and August 2004. In February and March 2004 only one site was surveyed (near the downstream inlet). In August 2004, the downstream inlet and stormwater basin were surveyed (SKM 2004).

Three frog species were recorded during the Baseline Survey, the Eastern Sign-bearing Froglet (*Crinia parinsignifera*), Spotted Grass Frog (*Limnodynastes tasmaniensis*) and the Eastern Banjo Frog (*Limnodynastes dumerilii*). These species are all commonly found in wetland and floodplain habitats along the River Murray (SKM 2004). The low diversity and abundance of frogs was attributed to the lack of water in the wetland.

Six frog species were recorded in Martin Bend following the environmental flows between September 2005 and January 2006. The three additional species (to those described above) were the Barking Marsh Frog (*Limnodynastes fletcheri*), Peron's Tree Frog (*Litoria peronii*) and the Southern Bell Frog (*Litoria raniformis*). The Southern Bell Frog is listed as vulnerable both in South Australia and nationally (under the EPBC Act). Southern Bell Frog is usually found in permanent lagoons, particularly those with emergent vegetation (Robinson 1995).

Frog census surveys (for EPA) have also been undertaken by local community at Martin Bend during 2003 and 2005 (B. Turner pers. comm. 2006). There were 4 frog species observed in 2003.

Future surveys will help to determine the importance of different habitats within the wetland as refuges for frogs and provide information on the impact of different water regimes on frog populations.

Macroinvertebrates

Macroinvertebrates were not sampled in Martin Bend during the Baseline Survey.

It is recommended to undertake macroinvertebrate surveys in the downstream inlet, permanent lagoon and in the stormwater and drainage basin after future filling events (incl. weir manipulations, pumping events, natural floods). The aim of monitoring would be to describe how the macroinvertebrate community in Martin Bend responds to wetland management. Macroinvertebrate surveys could also be undertaken in the temporary lagoons during future filling events.

VISITOR FACILITIES & RECREATION

Martin Bend is a highly-valued resource used by local community and visitors for recreational activities including bush walking, fishing, water skiing, bird watching, camping, barbeques and picnics.

Visitor access to the Martin Bend wetlands is via the walking trail along the banks of the River Murray. There are two entrances to the walking trail, one at the Berri Marina off Riverview Drive (western end), and via the road near the Berri Water Ski Club (eastern end).

The walking trail is a loop track that circles between the permanent and temporary lagoons in Martin Bend (Appendix 9a). Ongoing maintenance of the trail is recommended to ensure it does fall not into disrepair. Two sections of the walking trail crossover wetland channels. During high water levels the trail is inundated (e.g. Figure 11), which can cause erosion (H. Robertson pers. obs. 2005). It is recommended some works be undertaken to limit erosion.

Martin Bend has also been used for off-road vehicle driving, which has resulted in a number of non-formalised tracks being created. All unnecessary vehicle use on the floodplain is discouraged as it impacts on the growth and regeneration of native plant communities. It is recommended to investigate options to reduce vehicle access to Martin Bend.

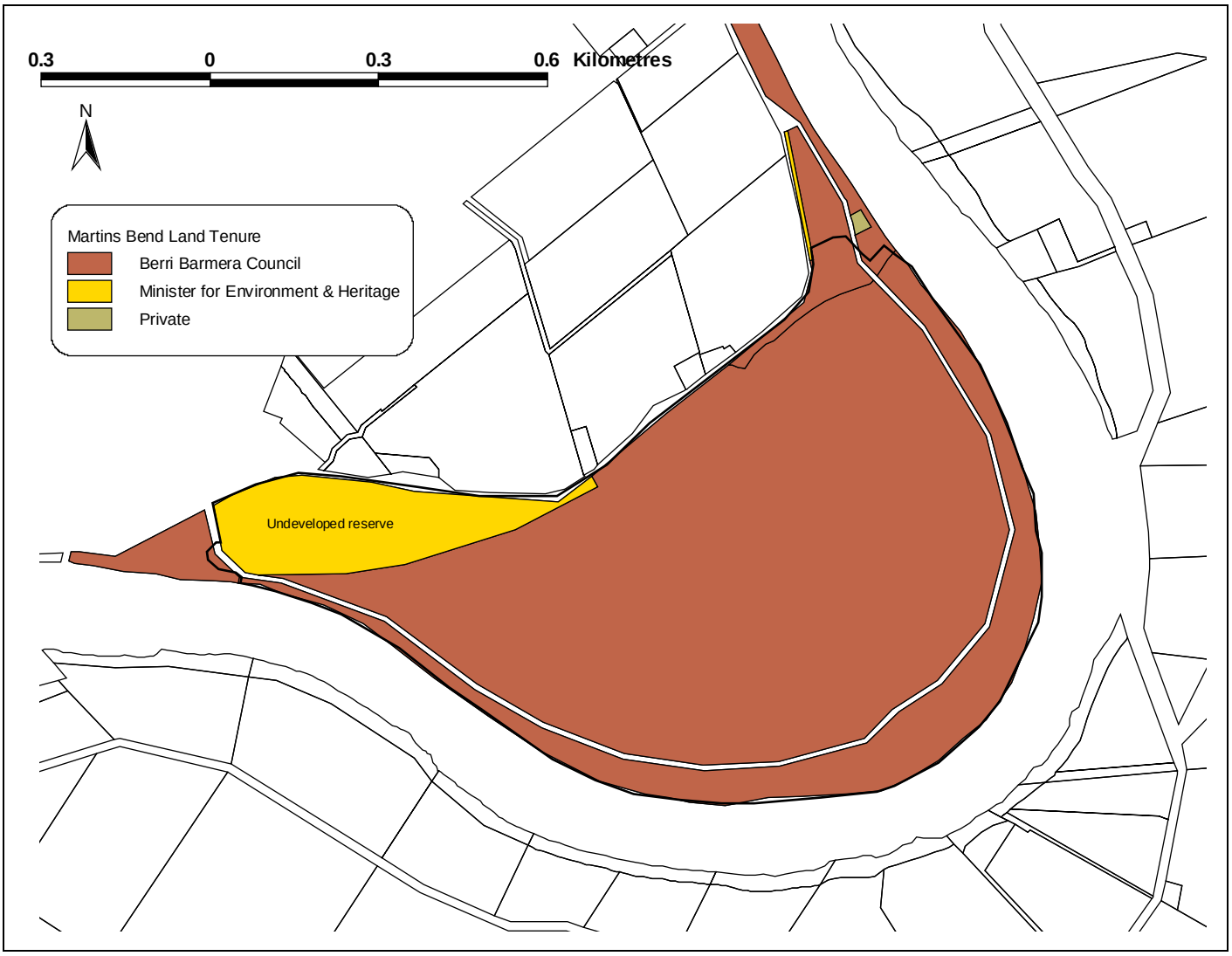
There is also potential to develop other visitor facilities in Martin Bend. This may include extending the walking trail, constructing a bird hide, installing seats adjacent to the river or wetlands, or other facilities to enhance the public use of Martin Bend.

Figure 11. Photographs of Martin Bend walking trail (during pumping project November 2005).

LAND TENURE, JURISDICTION AND MANAGEMENT ARRANGEMENTS

Land tenure

Martin Bend occurs on public land, excluding a small area of private land to the northeast (Map 4). The public (Crown) land includes – Recreation Reserve, Afforestation and Camping Reserve and Berri Barmera Council land (Map 4).



Map 4. Land tenure in Martin Bend

Jurisdiction authority and management arrangements

There are a number of different parties with jurisdictional authority of activities undertaken in Martin Bend, including the Berri Barmera Council and the Minister for Environment & Heritage.

Environmental management of Martin Bend is overseen by the Berri Barmera Local Action Planning Committee and the Martin Bend Steering Committee in association with the Berri Barmera Council and the South Australian Murray-Darling Basin Natural Resource Management Board. All management decisions need to be made in consultation with the Berri Barmera Council and other relevant stakeholders.

THREATS TO THE WETLAND

Identifying threats to the wetland is an important component in informing wetland managers of problems and ensuring management actions themselves do not pose a threat to wetland rehabilitation.

A number of threatening processes to the values of Martin Bend have been identified. These include **biological threats** such as weed infestations, **physical threats** such as salinisation of the wetland, and **management related threats**.

Some of the major threats to the values of Martin Bend include the high surface water salinity levels, seepage of saline groundwater, loss of native vegetation communities, and high abundance of pest animals and pest plants.

Table 5 lists the specific threats to Martin Bend, identifies their cause and potential impact, and describes the steps that have been taken or are to be taken to minimise their impact.

High abundance of Common Reed (*Phragmites australis*) along walking trail and adjacent to the permanent lagoon.

Build-up of silt and vegetation in downstream inlet is blocking the flow of water into the wetlands.

Table 5. Physical, biological and management-related threats to the values of Martin Bend.

THREATS			CAUSE	IMPACT	RESPONSE TO REDUCE THREAT
Physical	Actual	**Altered water regime**	▪ Construction of locks and weirs along the River Murray. ▪ Reduced frequency and duration of flood events. ▪ Use of Martin Bend as a stormwater disposal basin.	▪ Wetland has been permanently inundated for most of the past 70 years due to the high water level (pool level) maintained in the River Murray. ▪ In recent years, build-up of silt & vegetation has disconnected the wetland from the River Murray. ▪ The altered water regime, including lack of flood events, has resulted in the decline of native flora and fauna communities, and contributed to the accumulation of salt.	▪ Develop and implement a wetland operational plan (wetting and drying regime) to mimic the 'natural' water regime that would have occurred in the past, which also aims to limit the impact of high salinity in the wetland. ▪ Investigate options to increase frequency of flood events in Martin Bend.
	Actual	**Decline in surface water quality due to increased salinity levels**	▪ Elevated groundwater table under Martin Bend due to changed land uses in the region (i.e. irrigated agriculture). ▪ Reduced frequency and duration of flood events.	▪ High surface water salt levels in Martin Bend (>50,000 EC). ▪ Difficult to completely dry the wetland due to seepage of saline groundwater. ▪ Loss of native wetland flora and fauna due to high salt levels	▪ Investigate options to increase frequency of flood events in Martin Bend. ▪ Investigate options to reduce salt levels by inundating the wetland during weir manipulations, and via pumping of water from the River Murray (this includes leaving the regulator open so water can flow back into the river)
	Actual	**Decreased flow capacity of downstream inlet channel**	▪ High abundance of Cumbungi (*Typha* spp.) and Common Reed (*Phragmites australis*) in the downstream inlet ▪ Build-up of silt in downstream inlet.	▪ Vegetation and silt restricts the flow capacity of the inlet channel, which decreases the ability to control water levels in the wetland.	▪ Monitor the spread of Common Reed and Cumbungi, and build-up of silt in the downstream inlet in Martin Bend. ▪ If required, investigate options (e.g. dredging, cutting) to reduce abundance of vegetation and silt, and increase flow between wetland and river.
	Potential	**Release of sulphur gases (odour) from wetland sediment**	▪ Input of saline groundwater and altered surface water hydrology, may result in accumulation of sulfidic sediments and other materials which produce noxious odours.	▪ If noxious odours are produced in the future this will reduce the aesthetic values of Martin Bend, and surrounding areas (e.g. Berri).	▪ Investigate potential for sulphur odours to be produced in Martin Bend in the future, and if potential is high, identify management options to reduce the threat.
Biological	Actual	**Increased abundance of pest plants**	▪ Establishment of introduced weed species and other pest plants in Martin Bend, on the floodplain, in the inlet channel and on wetland fringes.	▪ A number of introduced pest plants including Willows (*Salix* sp.), Noogoora Burr (*Xanthium occidentale*) and Golden Dodder (*Cuscuta campestris*) have been observed in Martin Bend. Further invasion of these species and other introduced pest plants impacts on native vegetation communities. ▪ Lack of variation in water levels allows Cumbungi (*Typha* spp.) and Common Reed (*Phragmites australis*) to dominate some areas of the wetland (e.g. inlet channel) and restricts the establishment of other native wetland plants.	▪ Control the abundance of Noogoora Burr, Golden Dodder and other pest plants by physical removal and other control options. ▪ Monitor the spread of Common Reed and Cumbungi, and build-up of silt in the downstream and upstream inlets in Martin Bend. ▪ If required, investigate options (e.g. dredging, cutting) to reduce abundance of Common Reed and Cumbungi.
	Actual	**Increased abundance of pest animals**	▪ Invasion and establishment of aquatic and terrestrial pest animals.	▪ High rabbit abundance impact on native vegetation in Martin Bend. ▪ High abundance of Carp. ▪ Mosquitoes are also a potential health risk.	▪ Monitor and control rabbit abundance in Martin Bend. ▪ Undertake Carp control management actions (e.g. regular drying of wetland) ▪ Monitor the abundance of mosquitoes in response to different water regimes.
Management	Actual	**Decline in condition of habitat caused by vehicles, and other recreation related activities**	▪ Martin Bend is accessible to the public. Vehicle use on an extensive network of tracks, and other activities including firewood removal, are a threat to the ecosystem.	▪ Vehicle driving across the floodplain on a large number of tracks leads to degradation of native vegetation, contributes to soil erosion, and prevents regeneration of plants. ▪ Removal of woody debris reduces important habitat for ground-dwelling fauna.	▪ Rationalise the network of tracks (e.g. block superfluous tracks and revegetate with floodplain species). ▪ Formalise camping areas with wooden posts, and provide rubbish collection facilities. ▪ Develop and install interpretation boards at the entrance to the floodplain to encourage the responsible public use and enjoyment of the wetland.
	Potential	**Lack of continued community involvement in management of Martin Bend.**	▪ Lack of a community group involved in the management of Martin Bend.	▪ No community ownership of Martin Bend. ▪ No integrated community management or monitoring in Martin Bend.	▪ Establish a group comprised of interested local community members individuals to undertake wetland management and wetland monitoring in Martin Bend. ▪ Undertake capacity building activities to support the long-term management of Martin Bend by local community.

MANAGEMENT OBJECTIVES

The management objectives for Martin Bend were previously listed on page 7. These are summarised below:

- Increase frequency of environmental flows to provide habitat for native fauna, and promote regeneration of native vegetation.
- Reduce surface water salinity levels in the wetland via a coordinated approach to management.
- Manage stormwater drainage.
- Plan and implement an ongoing revegetation program in Martin Bend involving local community
- Control the abundance of noxious weeds and other pest plants.
- Control the abundance of pest animals, particularly rabbits and introduced species of fish.
- Maintain a vibrant community group with the capacity to undertake wetland management.
- Improve existing recreational facilities in Martin Bend, including maintenance of walking trail, and identify sites of significant cultural or social heritage.
- Improve community awareness and education about wetland management.
- Formalise ongoing management arrangements with key stakeholders.

Table 6 lists the specific management objectives for Martin Bend, and describes the management actions, resources and management priority to address these objectives. Table 6 also outlines a timetable for implementing the management actions in Martin Bend.

These objectives have been developed through consultation with the Martin Bend Steering Committee and other stakeholders.

The objectives will be reviewed and updated as necessary.

Future management objectives for Martin Bend will be guided by an adaptive management approach ('learning by doing'). The ongoing monitoring program will also provide results to inform the management decisions for Martin Bend.

Table 6. Management objectives for Martin Bend, including specific management aims, management actions and priorities.

MANAGEMENT OBJECTIVES	SPECIFIC MANAGEMENT AIMS	ACTIONS / ACTIVITIES	RESOURCES	TIMETABLE	PRIORITY
Increase the frequency of environmental flows in the permanent and temporary lagoons in Martin Bend - to provide habitat for native fauna and promote the regeneration of wetland and floodplain vegetation.	▪ Inundate the permanent lagoon for between 50-75% of the period between July 2006 and July 2009. ▪ Inundate the temporary lagoons on 2 occasions between July 2006 and July 2009. ▪ Observe an increase in abundance and diversity of wetland birds. Including at least 100 individual wetland birds during the wetting cycle, and 2 threatened species. ▪ Maintain populations of at least 4 species of frog, with an aim of increasing the diversity of frogs. ▪ Maintain populations of at least 3 species of native fish. ▪ Observe no decline in tree health scores of River Red Gum and Black Box over the next 5 years. ▪ Observe an increase in the diversity and extent of emergent and floating wetland plants in Martin Bend, including wetland plants that currently occur in the downstream inlet (e.g. *Myriophyllum* sp, *Ludwigia peploides* ssp. *montevidensis*).	▪ Implement Wetland Operational Plan. ▪ Investigate options to increase frequency of flood events in Martin Bend (weir manipulations, pumping, decrease sill levels of inlets). ▪ Monitor the abundance of native fauna at different times of the year in response to wetland management. ▪ Monitor the change in wetland and floodplain vegetation in response to wetland management. ▪ Monitor change in water levels, and surface water and groundwater salinity in response to wetland management. *Note: Inundation of floodplain areas dependent on flood events in the River Murray (e.g. > 50,000 ML/day).* ▪	▪ Require a valid water licence to receive a River Murray water allocation. ▪ Technical expertise to support monitoring program.	▪ See Wetland Operational Plan and Monitoring Program for further details.	**1**
Reduce surface water salinity levels in the wetland via a coordinated approach to management, including flushing the wetland and investigating options to reduce the input of saline groundwater.	▪ Observe surface water salinity levels < 10,000 µS/cm (EC) for at least 50% of the duration of the wetting cycle. ▪ Investigate options to decrease the sill level of the downstream inlet by December 2006. ▪ Investigate options to decrease the sill level of Upstream Inlet 1 by July 2007. ▪ Fund a research institution to study the surface water and groundwater interactions in Martin Bend (and develop a long-term strategy to manage surface water salinity) by July 2008.	▪ Implement Wetland Operational Plan (which reduces the impact of salinity on the wetland by providing a source of fresher water) ▪ Investigate options to increase frequency of flood events in Martin Bend (weir manipulations, pumping, decrease sill levels of inlets). ▪ Fund a research institution to undertake hydrological research in Martin Bend. ▪ Monitor change in surface water and groundwater salinity in response to management.	▪ Require a valid water licence to receive a River Murray water allocation. ▪ Technical expertise to support monitoring program. ▪ Research institute to examine hydrological management options.	▪ See Wetland Operational Plan and Monitoring Program for further details. ▪ Saline water management is ongoing.	**1**
Manage stormwater drainage to limit the negative impact it has on the ecosystem, while investigating options to utilise the stormwater for wetland management.	▪ Investigate options to move the location of the stormwater outlet by December 2006 ▪ Investigate options to use stormwater runoff for wetland management in Martin Bend with key stakeholders by July 2007.	▪ Organise a meeting with relevant stakeholders and technical experts to discuss stormwater management in Martin Bend. ▪ Investigate options to utilise stormwater for wetland management with relevant stakeholders and technical experts.	▪ Technical expertise to identify stormwater management options.	▪ Stormwater management options identified by July 2007.	**3**
Plan and implement an ongoing revegetation program in Martin Bend involving local community.	▪ Finalise a 5 year revegetation strategy for Martin Bend by December 2006. ▪ Undertake revegetation at 2 sites in Martin Bend by December 2007.	▪ Consult with Berri Lions Club, Greening Australia, local schools and other stakeholders to develop a 5 year revegetation strategy. ▪ Undertake revegetation (e.g. direct seeding or planting tube stock) at selected sites in Martin Bend involving the local community.	▪ Technical expertise to support revegetation program.	▪ Revegetation strategy by December 2006 ▪ Revegetation completed at 2 sites by December 2007.	**2**
Control the abundance of noxious weeds and other pest plants.	▪ Control (or eradicate) the populations of Willow, Noogoora Burr, Golden Dodder, African Boxthorn and other pest plants, and over 5 years observe a decrease in the abundance of these species. ▪ Observe no increase in the area of the wetland dominated by Cumbungi and Common Reed over the next 5 years.	▪ Routinely monitor the distribution and abundance of pest plants in Martin Bend (in conjunction with SAMDB NRMB). ▪ Undertake native flora and fauna surveys prior to implementing control actions. ▪ Implement control programs for pest plant populations as necessary (i.e. physical removal, herbicide), particularly African Boxthorn, Noogoora Burr and Golden Dodder (with SAMDB NRMB). ▪ Map the extent of Cumbungi and Common Reed in the wetland, and monitor the change in abundance in response to different water regimes (wetting and drying).	▪ Technical expertise to map pest plants distribution. ▪ SAMDB NRMB to coordinate pest plant control activities.	▪ Timetable for control and monitoring activities recommended by the SAMDB NRMB.	**2**

MANAGEMENT OBJECTIVES	SPECIFIC MANAGEMENT AIMS	ACTIONS / ACTIVITIES	RESOURCES	TIMETABLE	PRIORITY
Control the abundance of pest animals in Martin Bend, particularly rabbits and introduced species of fish (e.g. Carp).	▪ Undertake rabbit control at least 2 times per year, and observe a decrease in the number of rabbits over 5 years. ▪ Undertake Carp control actions at least 2 times per year, and observe a decrease in the number of Carp caught over 5 years.	▪ Routinely monitor the distribution and abundance of pest animals in Martin Bend (in conjunction with SAMDB NRMB). ▪ Undertake rabbit control projects in conjunction with SAMDB NRMB. ▪ Undertake Carp control projects in conjunction with SAMDB NRMB.	▪ Technical expertise to survey pest animal populations. ▪ SAMDB NRMB to coordinate pest animal control activities.	▪ Timetable for control and monitoring activities recommended by SAMDB NRMB.	**2**
Maintain a vibrant community group with the capacity to undertake wetland management and a wetland monitoring program.	▪ Continue with at least 4 monitoring days per year with the Martin Bend Wetland Group. ▪ Organise a least 2 meetings per year with the Martin Bend Steering Committee.	▪ Invite members of the community to join to Martin Bend Steering Committee ▪ Coordinate wetland monitoring days. ▪ Hold meetings with the Martin Bend community group. ▪ Invite staff from government departments to meetings.	▪ BBLAP support	▪ 4 monitoring days between July 2006 & July 2007. ▪ 2 committee meetings between July 2006 & July 2007.	**1**
Improve the existing recreational facilities in Martin Bend, including maintenance of the walking trail and development of additional visitor facilities, and identify and conserve the sites of significant cultural and/or social heritage.	▪ Undertake maintenance works on walking trail at least every 2 years. ▪ Investigate options to develop additional visitor facilities with key stakeholders by December 2006. ▪ Undertake works to remove vehicle access from 50% of the existing tracks by July 2007. ▪ Identify sites of significant cultural and/or social heritage in Martin Bend by December 2006 (and conserve as necessary).	▪ Determine which areas of the walking trail may require maintenance, and undertake works as required. ▪ Consult with key stakeholders and local community about what additional visitor facilities may be developed in Martin Bend (e.g. extend walking trail, bird hide). ▪ Rationalise the network of tracks (e.g. Block superfluous tracks with wooden posts and signpost as revegetation areas) and formalise camping areas. ▪ Monitor visitor numbers at different times of the year. ▪ Identify sites of cultural and social heritage in Martin Bend.	▪ Technical advice on walking trails maintenance, visitor facilities, and off-road vehicle track works required. ▪ Technical advice on sites of cultural and social heritage. ▪ BBLAP & Berri Lions Club support	▪ Walking trail maintenance every 2 years (start 2006). ▪ Discuss visitor facilities by December 2006. ▪ Works on off-road vehicle tracks by July 2007. ▪ Significant sites identified by December 2006.	**2**
Improve community awareness and education about wetland management by promoting recreation, by keeping local community informed, and involving local schools.	▪ Update local community about wetland management in Martin Bend with 2 newsletters per year. ▪ Develop a brochure to promote the walking trail and visitor facilities in Martin Bend by December 2006. ▪ Organise at least 2 activities per year in Martin Bend with local schools.	▪ Create a mailing list of interested local community members and relevant stakeholders to distribute newsletters, monitoring day invites, etc. ▪ Circulate newsletters and other media articles about wetland management in Martin Bend. ▪ Involve local schools in monitoring days, revegetation programs and other activities.	▪ BBLAP & SA MDB NRMB support	▪ 2 newsletters per year. ▪ Develop brochure by December 2006. ▪ 2 activities per year with local schools.	**1**
Formalise ongoing management arrangements with the key stakeholders.	▪ Key stakeholders to sign a management agreement for Martin Bend by December 2006.	▪ Circulate the Wetland Management Plan to stakeholders, and formalise management arrangements via a management agreement signed by all key stakeholders.		▪ Due December 2006	**1**

WETLAND OPERATIONAL PLAN (WATER REGIME)

WETLAND OPERATIONAL PLAN (Permanent lagoon)

This wetland operation plan outlines the recommended water regime for the permanent lagoon in Martin Bend over the next 3 years.

Managing a water regime in the temporary lagoons is dependent on high flows in the River Murray (above 13.33 mAHD) or by pumping water into the wetland (refer 'Pumping additional water into Martin Bend').

The wetland operational plan describes the phases of wetting and drying, which are managed by opening and closing the regulator on the downstream inlet. This regulation structure enables Martin Bend to receive an environmental water allocation from the River Murray. The operational plan has an initial three-year cycle, between 1 July 2006 and 30 June 2009.

Figure 12 provides a pictorial representation of the wetting and drying cycle in the permanent lagoon of Martin Bend. The recent fluctuation in the water level (between July 2005 and July 2006) is also included in Figure 12.

A detailed description of the wetland operational plan, including the timing and rate of inundation, and key expected responses is provided in Table 7.

The aim of the wetting and drying cycle is to fluctuate water levels in the wetland, and thereby, increase the diversity of habitat for native wetland flora and fauna, and provide a source of fresher water to the wetland.

The predicted water allocation for the period 1 July 2006 to 30 June 2009 is approximately 205 ML (refer Appendix 12 for the water volume calculation).

IMPACT OF STORMWATER, DRAINAGE & GROUNDWATER SEEPAGE

Stormwater drainage, irrigation drainage and groundwater seepage contribute to the water regime in Martin Bend. Management of the wetting and drying cycle in Martin Bend has to consider how these inputs affect the wetland operational plan.

Stormwater and drainage inputs are usually restricted to the disposal basin and to a lesser extent to the northern-most temporary lagoon (T3). Neither of these wetlands are connected to the permanent lagoon at normal pool level.

The impact of groundwater seepage is not well understood. During prolonged periods of dry conditions shallow surface water is observed in permanent lagoon and temporary lagoons, which may be groundwater seepage (H. Robertson pers. obs. 2005). The groundwater is a source of saline water that mixes with surface water when the wetland is inundated.

It is recommended that during future attempts to dry and inundate the wetland, the water levels and salinity levels are frequently monitored to identify the sources of water inflow.

Permanent Lagoon Only

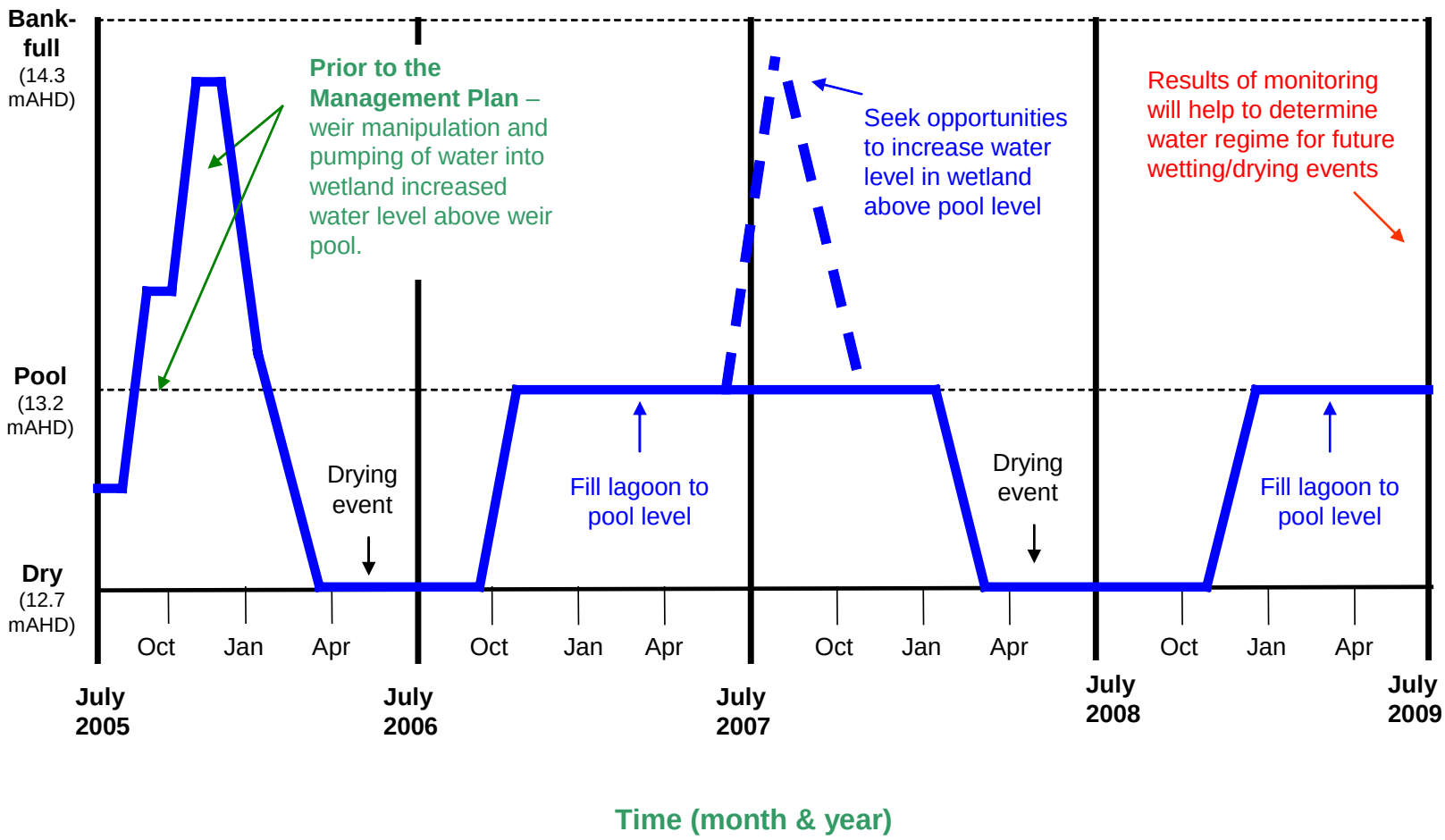


Figure 12. Wetting and drying phases of the Wetland Operational Plan for Martin Bend (Permanent Lagoon only).

Table 7. Wetland Operational Plan for Martin Bend (Permanent Lagoon only).

Year		Action	Timing	Rate	Activity	Expected response	Water Use
Year 1	July 2005 to June 2006	Increase water level by weir manipulation	Sept 2005 to Oct 2005	Increased 40 cm over 30 days.	Open regulator to allow water to flow into Martin Bend.	▪ Provide habitat for aquatic fauna, particularly water birds, frogs, fish and invertebrates. ▪ Release of nutrients from wetland bed. ▪ Germination of emergent plants. ▪ Decrease surface water salinity level (dilution of salt concentration). ▪ Regeneration of River Red Gum trees ▪ Create or improve freshwater lens under the wetland.	Approx. 20 ML used
		Increase water level by pumping	Oct 2005	Increased 60 cm over 6 days. Approx. 100 ML of water pumped	Close regulator, water pumped into the downstream inlet from the River Murray.		Approx. 100 ML used
		Drying event	Nov 2005 to July 2006	Evaporation	Keep regulator closed.	▪ Consolidation of the wetland bed sediment. ▪ Germination and establishment of dry wetland bed plants. ▪ Reduce abundance of aquatic pest plants.	0 ML
Year 2	July 2006 to June 2007	Drying event	July 2006 to Sept 2006	Evaporation	Keep regulator closed.		0 ML
		Fill wetland to pool level	Oct 2006 to June 2007	Fill wetland at ~ 1cm/day.	**Acquire long-term water licence.** Open regulator to allow water to flow into Martin Bend.	▪ Provide habitat for aquatic fauna, particularly water birds, frogs, fish and invertebrates. ▪ Release of nutrients from wetland bed. ▪ Germination of emergent plants. ▪ Decrease surface water salinity level (dilution of salt). ▪ Create or improve freshwater lens under the wetland. ▪ Regeneration of River Red Gum trees	80 ML
Year 3	July 2007 to June 2008	Maintain water level at pool level	July 2007 to January 2008	-	Keep regulator open.		50 ML
		Drying event	February to June 2008	Evaporation	Keep regulator closed.	▪ Consolidation of the wetland bed sediment. ▪ Germination and establishment of dry wetland bed plants. ▪ Reduce abundance of aquatic pest plants.	0 ML
Year 4	July 2008 to June 2009	Drying event	July 2008 to Oct 2008	Evaporation	Keep regulator closed.		0 ML
		Fill wetland to pool level	Nov 2008 to June 2009	Fill wetland at ~ 1cm/day.	Open regulator to allow water to flow into Martin Bend.	▪ As above wetting events	75 ML

MODIFYING THE WETLAND OPERATIONAL PLAN

The wetland operational plan is only a guide and should be modified if monitoring results provide evidence to support a change in management. Natural processes, such as a River Murray flood event may also require the wetland operational plan to be modified.

When implementing a water regime it is important to consider the different stages in the wetting and drying cycle of the wetland, and their impacts on the physical and biological values of the ecosystem. These stages and their impact on the wetland are described in *Your Wetland: Hydrology Guidelines* (Tucker *et al*. 2002) and summarised in Appendix 11.

The wetland operational plan is to be reviewed in June 2009, to determine whether or not the plan and management objectives are appropriate for Martin Bend.

PUMPING ADDITIONAL WATER INTO MARTIN BEND

Prior to river regulation the temporary wetlands in Martin Bend would have been frequently inundated.

Under current conditions, inundation of the temporary lagoons is dependent on high flows in the River Murray (above 13.33 mAHD), or by pumping water directly into the wetland.

It is recommended that pumping of water into the temporary wetlands occurs at least once every 2-3 years. It is also recommended that the volume of water pumped into the wetland is varied, to inundate the wetland to different water levels, and to increase the duration of inundation in certain years.

A proposed environmental watering plan for temporary lagoons in Martin Bend is outlined in Figure 13.

The volume of water required to pump water into the permanent and temporary lagoons in Martin Bend can be estimated from Table 3.

Please note that weir manipulations in River Murray also provide a mechanism to flood the temporary lagoons in Martin Bend.

Do's and Don'ts for wetting and drying wetlands (adapted from Tucker *et al*. 2002)

When wetting and drying a wetland there are a number of general rules, which should be followed where possible. These are:

1. Filling should be slow - less than 1cm per day.
2. Drying should be for more than 3 months.
3. Drying should NOT be for longer than 6 months during warm months as it increases the risk of groundwater seepage into the wetland.
4. Short wet periods after long dry periods are not encouraged.
5. Benefits of wetting and drying will not be fully seen if wetting and drying periods are short.
6. Over bank flooding should not be maintained for long periods of time as it can cause stress and death to riparian vegetation.
7. The rate of drying the wetland should not be greater than 5cm/day.

Temporary Lagoons

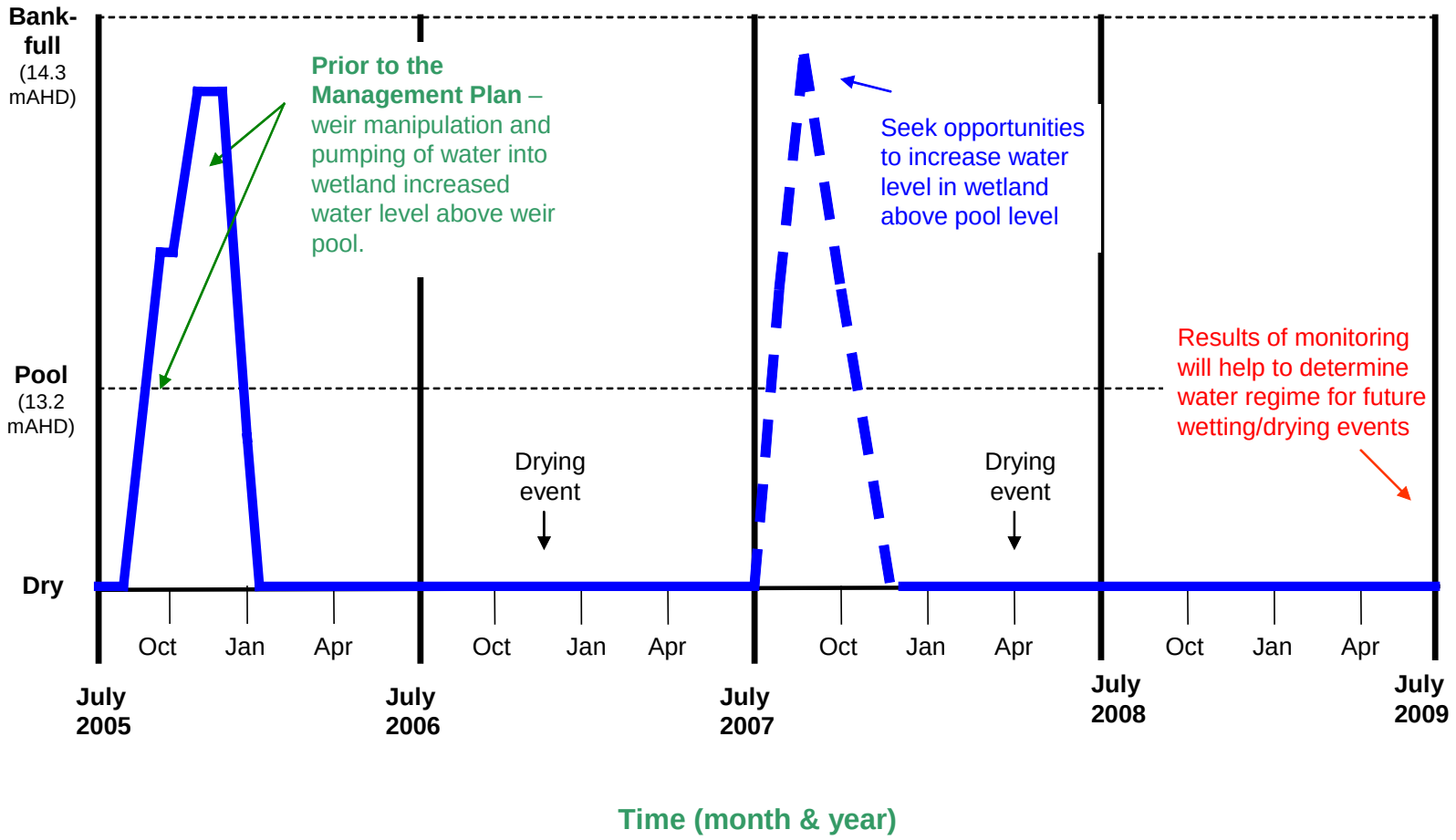


Figure 13. Proposed environmental water pumping plan for Martin Bend

FLOOD EVENTS

Flood events still impact on Martin Bend during periods of high flow (e.g. > 50,000 ML/day flow in River Murray). Therefore, in addition to the Wetland Operation Plan (described previously), it is important to have clear objectives and actions for the management of flood events.

The inflow of water during flood events cannot generally be managed, due to over bank flooding and subsequent inundation of the floodplain and wetlands. However, when the water level in the River Murray has receded, there are a number of options to manage the water regime within Martin Bend.

After the flood event has passed high water levels may be maintained by closing the downstream regulator, and holding water up to a height of 14.26 mAHD (top of regulator). The ecological benefits of increasing the water level and flood duration will include improved health of water-stressed wetland and floodplain vegetation, provision of habitat for aquatic fauna such as frogs, wetland birds and macroinvertebrates, decreased surface water salinity, and possible creation of a freshwater lens beneath the wetland.

Flood events will also lead to the flushing of salts from the floodplain and wetland into the River Murray. During over bank flows the flushing of salts cannot be controlled. The discharge of salt to River Murray can only be managed once the water levels in the wetland have receded (below the height of the regulator).

If the regulator is closed to maintain high water levels (described above), this will limit the removal of salt from the system. Therefore, the alternative option to holding floodwaters in the wetland, is to leave the downstream regulator open and allow floodwaters to recede naturally. Given the high salinity levels in Martin Bend the removal of salt from the ecosystem may be considered more important than prolonging the duration of the flood event. However, the salinity impact to the River Murray needs to be considered if this strategy is employed.

Many of the upstream inlets into Martin Bend commence to flow at approximately 50,000 ML/day. Decreasing the upstream sill levels (e.g. to allow for 35,000 ML/day flows) could be investigated to increase the flooding potential. However, the negative impacts of decreasing the sill level, including intercepting saline groundwater, erosion, and degradation of wetland habitat and native vegetation, need to be comprehensively researched before such a management strategy is implemented.

It is recommended that during and after flood events, management actions that impact on the water regime in Martin Bend are undertaken in consultation with the BBLAP, relevant stakeholders and technical experts (e.g. Wetland Officer from the SA MDB NRM Board).

PROPOSED ON-GROUND WORKS

REVEGETATION

The Berri Lions Club in association with BBLAP and other community members have undertaken some revegetation projects (planting seedlings) in Martin Bend over the past few years. The area of revegetation was adjacent to the stormwater disposal basin. River Red Gum and Black Box seedlings were the main species that were planted (A. Thurmer pers. comm. 2006).

Appendix 9a shows the location of the previous revegetation works in Martin Bend.

Berri Lions Club are interested in continuing with revegetation projects. The aim of revegetation is to increase the abundance of trees and shrubs that would have previously occurred on the floodplain.

Recommended plant species include: Black Box (*Eucalyptus camaldulensis*), River Cooba (*Acacia stenophylla*), River Saltbush (*Atriplex rhagodioides*), Dryland Tea-tree (*Melaleuca lanceolata*) Creeping Boobialla (*Myoporum parvifolium*) Spreading Emubush (*Eremophila divaricate*) and Bignonia Emubush (*Eremophila bignoniiflora*) (M. Durant pers. comm. 2006). Appendix 9b provides recommendations for revegetation in Martin Bend.

Appendix 1 lists the results from soil analysis at four potential revegetation sites in Martin Bend. Notably, one of the recommended revegetation sites has very high salinity levels, and therefore planting would not be recommended in this area.

Priority sites for revegetation include areas adjacent to the the walking trail between the stormwater ponds and the downstream inlet (Appendix 9a). **Please note:** The impact of soil salinity and groundwater at all revegetation sites needs to be carefully considered before works are undertaken.

Existing revegetation site in Martin Bend.

Potential revegetation site adjacent to walking trail.

STORMWATER & DRAINAGE DISPOSAL BASIN

The stormwater and drainage disposal basin in Martin Bend was last upgraded in the 1970s.

There is potential to further upgrade the stormwater ponds by undertaking some minor on-ground works. These works would have to be approved by the Berri Barmera Council, EPA, DWLBC and other stakeholders before being undertaken.

The proposed works include:

- Moving the location of the stormwater outlet (to River Murray), to increase the circulation of stormwater (increase the removal of pollutants from the stormwater)
- Increasing the size (capacity) of the stormwater basin (increase wetland habitat for flora and fauna)
- Creating an island in the stormwater basin to provide a roosting area for waterbirds
- Install rubbish traps across the stormwater outlet (to remove litter before it enters the River)
- Extend Martin Bend walking trail around stormwater basin and provide observation points

In combination, the proposed works would:

- Improve the water quality of water entering the River Murray
- Create an example of environmental management close to Berri, which also provides recreation facilities for local community and visitors (bird watching, walking)
- Enhance wetland habitat for native flora and fauna (e.g. waterbirds, frogs)

Refer to Appendix 10 for a map of the stormwater and drainage disposal basin, and proposed works.

Existing stormwater outlet to the River Murray.

View of stormwater ponds from Riverview Drive.

OTHER ON-GROUND WORKS

In addition to revegetation and the stormwater and drainage basin works, there are a number of other general wetland management activities that would enhance Martin Bend. These include:

- Maintenance (and possibly extend) the Martin Bend walking trail (incl. works to control erosion)
- Maintenance (including clearing) of the pipes and culverts in wetland channels
- Works to reduce vehicle access across the wetland and floodplain

- Upgrades of regulated and non-regulated structures (see ‘Water Flow Structures’ for details)

MONITORING

Monitoring is a vital component of wetland management. Monitoring allows the collection of physical and biological data that can be used to determine the success or failure of a management action. It can also be used to adjust or change management actions in response to changes in the wetland ecosystem.

Ongoing monitoring in Martin Bend will be carried out by members of the Martin Bend Wetland Group with assistance from Berri Barmera LAP and the South Australian Murray-Darling Basin Natural Resources Management Board.

The monitoring program is outlined in Table 8, which includes monitoring of flora, fauna, groundwater and surface water. Notably, there is also the possibility for opportunistic monitoring outside the scope of the monitoring program, such as observations of threatened species of birds.

To ensure the data collected are comparable to the Baseline Survey, it is recommended monitoring sites in Martin Bend are based on those used in the Baseline Survey. Locations of the monitoring sites used in community monitoring are shown in Appendix 14.

The techniques for monitoring physical and biological parameters in Martin Bend are to be based on the methods outlined in *Your Wetland: Monitoring Manual* (Tucker 2004).

Vegetation and water quality monitoring in action at Martin Bend.

Table 8. Monitoring Program for Martin Bend

	Monitoring Activity	Technique	Time required	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Priority	Responsibility / Coordination
Flora	Vegetation	Photopoint assessment	½ day ^			√			√			√			√	**HIGH**	BBLAP & Martin Bend Wetland Group (MBWG)
		Quadrat based survey and line intercept	2 days ^											√		**LOW**	BBLAP and MBWG, with support from NRM Board Wetland Project Officer
		Visual health assessment (e.g. River Red Gums)	1 day			√			√			√			√	**HIGH**	BBLAP & MBWG
		Mapping of pest plants (e.g. Cumbungi, Burr)	2 days											√		**MEDIUM**	Loxton Waikerie Animal & Plant Control Board
Fauna	Birds	Fixed area search	½ day			√						√				**MEDIUM**	BBLAP & MBWG
		Colonial nesting	3 hours			√						√				**MEDIUM**	BBLAP & MBWG
	Fish	Fyke, dip, seine nets and shrimp traps	2 days ^			√						√				**HIGH**	BBLAP Officer
	Frogs	Recording frog calls	2 hours									√			√	**MEDIUM**	BBLAP & MBWG
	Macroinvertebrates	Dip net sampling	½ day ^			√						√				**MEDIUM**	BBLAP & MBWG
Management - related	Groundwater	Groundwater depth and salinity from piezometers *	½ day			√			√			√			√	**HIGH**	BBLAP & MBWG
		Assessment of freshwater lens (depth and salinity) ^ ^	½ day			√			√			√			√	**HIGH**	NRM Board Wetland Project Officer with support from BBLAP
	Surface water	Water quality (e.g. salinity, pH, turbidity)	3 hours			√			√			√			√	**HIGH**	BBLAP & MBWG
		Water level monitoring *	1 hour	√	√	√	√	√	√	√	√	√	√	√	√	**HIGH**	BBLAP & MBWG
	Structure management	Log all structure management actions (date, action, reason for action, flow conditions)	1 hour	On going												**HIGH**	BBLAP & MBWG
		Maintain structures to ensure adequate free passage for water flow and aquatic organisms	1 day ^	On going												**HIGH**	BBLAP & MBWG
Other	Data management	Update and file all data (2 copies kept in separate locations)	1-2 hours per month	On going												**HIGH**	NRM Board Wetland Project Officer with support from BBLAP
		Analyse biological and physical data and relate to management actions	1 day		√			√			√			√		**HIGH**	NRM Board Wetland Project Officer
		Update Monitoring Log Book	1 hour	On going												**HIGH**	BBLAP & MBWG
		Review wetland operational plan	1-2 days ^	As required - minimum every 3 years												**HIGH**	BBLAP & MBWG and other relevant stakeholders with support from NRM Board Wetland Project Officer
		Report to DWLBC of any changes to the management plan	2 hours	As required – minimum annually												**HIGH**	BBLAP Officer with support from NRM Board Wetland Project Officer

Refer to *Your Wetland: Monitoring Manual* (Tucker 2004) for details of monitoring methods.

^ More than one person is required to perform monitoring method
^ ^ Dependent on the installation of nested piezometers
* Increase frequency of water level monitoring during drawdown and refilling.

Note:
There is also the possibility for opportunistic monitoring outside the scope of the monitoring program, such as observations of threatened species of birds.

EVALUATION AND REVIEW

Evaluation and review of the objectives and actions is required throughout the period of the Wetland Management Plan. This informs the community and wetland managers of the effect that the management actions are having on the wetlands' physical and biological characteristics.

Under an adaptive management approach, the results from the monitoring program can provide evidence to reconsider or alter the management objectives and actions. This may include evidence of increased surface water salinity, which threatens aquatic biota and triggers an immediate management response, or evidence that takes longer to become obvious, such as seeing improvements in long-lived vegetation. The SA Murray-Darling Basin Natural Resources Management Board can assist with the analysis and evaluation of the monitoring data.

The wetland operational plan (water regime) will need to be evaluated at the end of the initial four-year cycle (30 June 2009). This Martin Bend Wetland Management Plan is also to be reviewed by the end of June 2009.

REPORTING

In order to comply with the water licence from the Department of Water, Land and Biodiversity Conservation (DWLBC), a reporting element is required. DWLBC require that they be informed of any changes to the management objectives, wetland operational plan and/or the monitoring program. This is to ensure that the changes are in agreement with the wetland management plan guidelines, and to ensure the water allocation arrangements for the wetland are still appropriate.

It is important that records be kept of all monitoring data and management actions, indicating dates, actions carried out and results. This data should be stored in an easy to use and accessible format in a central location.

Temporary lagoon (T2) in Martin Bend after the pumping project (November 05).

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APPENDICES

APPENDIX 1. Soil nutrient, salinity and pH levels from 4 sample sites near the Stormwater Basin in Martin Bend.

Parameter	Unit	Site			
		1 (NRST)	2 (PA)	3 (NA)	4 (RST)
Phosphorus	mg/kg	54	41	29	29
Potassium	mg/kg	226	401	314	153
Sulphur	mg/kg	139	16.6	705	120
pH (1:5 water)	-	7.3	8.5	7.7	5.9
pH ($CaCl_2$)	-	6.9	7.9	7.5	5.4
Salinity	µS/cm (EC)	1390	330	6330	1150
Soil Texture	-	Loam	Loam	Clay Loam	Loam
Organic Carbon	%	1.58	0.79	0.72	0.75
Nitrate	mg/kg	6	28	18	4
Ammonium	mg/kg	2	3	7	7
Reactive Iron	mg/kg	1009	588	898	900

Source: D. Mathews pers. comm. 2006

Key to sites (*all samples taken near the Stormwater Basin in Martin Bend*):
NRST Non-river side of walking track
PA Planted area (revegetation)
NA Proposed area (for revegetation
RST River side of walking track

APPENDIX 2. Groundwater table elevation and groundwater salinity levels in Martin Bend

Appendix 2a. Groundwater table elevation (mAHD) recorded in four piezometers in Martin Bend.

Piezo-meter	Ground elevation	Date								
		3-2-04	27-2-04	24-6-04	29-6-04	19-7-04	27-8-04	28-9-05	3-11-05	05-1-06
BE 16	15.28	12.96		13.09		13.09	13.07			
MB 3	16.56	12.69	12.51	13.09			13.10			
MB 5	14.81	13.00	12.92	13.15	13.09		13.13	13.31	13.76	13.38
LOX 1505	14.42	13.10	13.04	13.13	13.09		13.16	13.24	13.57	12.44

Refer to Appendix 3 for location of the piezometers. Note: Data from wells MB6 and MB7 not included due to possible errors.

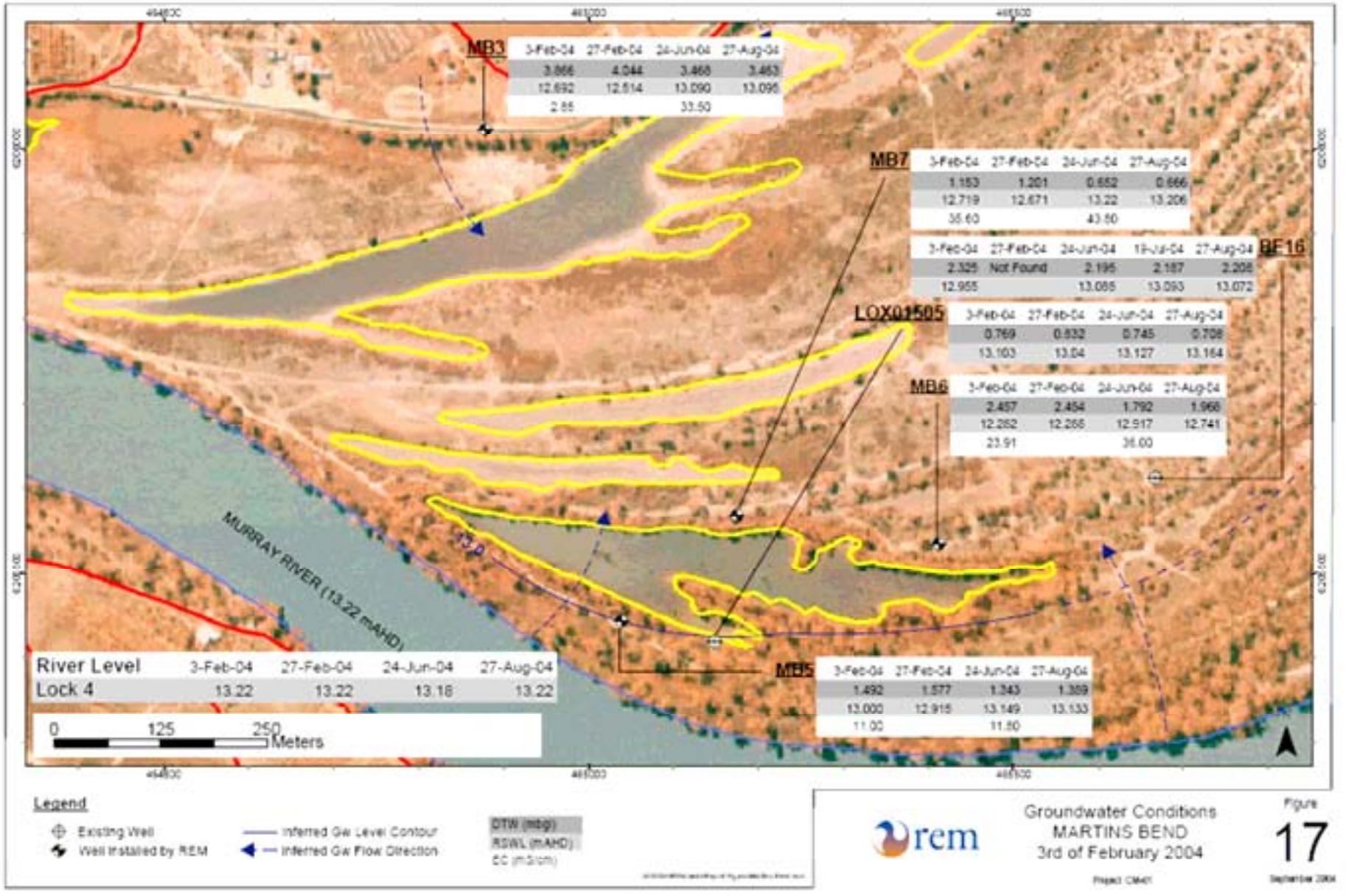
Appendix 2b. Groundwater table salinity recorded in five piezometers in Martin Bend

Piezometer	Date					
	3-2-04	24-6-04	29-6-04	28-9-05	3-11-05	5-1-06
MB 3	2850	33500				
MB 5	11000	11500	12170	10840	12880	18560
MB 6	23910	35000	35200	32300	31800	30900
MB 7	35600	43800	43900	44400	45200	45300
LOXO1505			7200	2200	8300	11150

Refer to Appendix 3 for location of the piezometers. Note: No data available from BE 16.

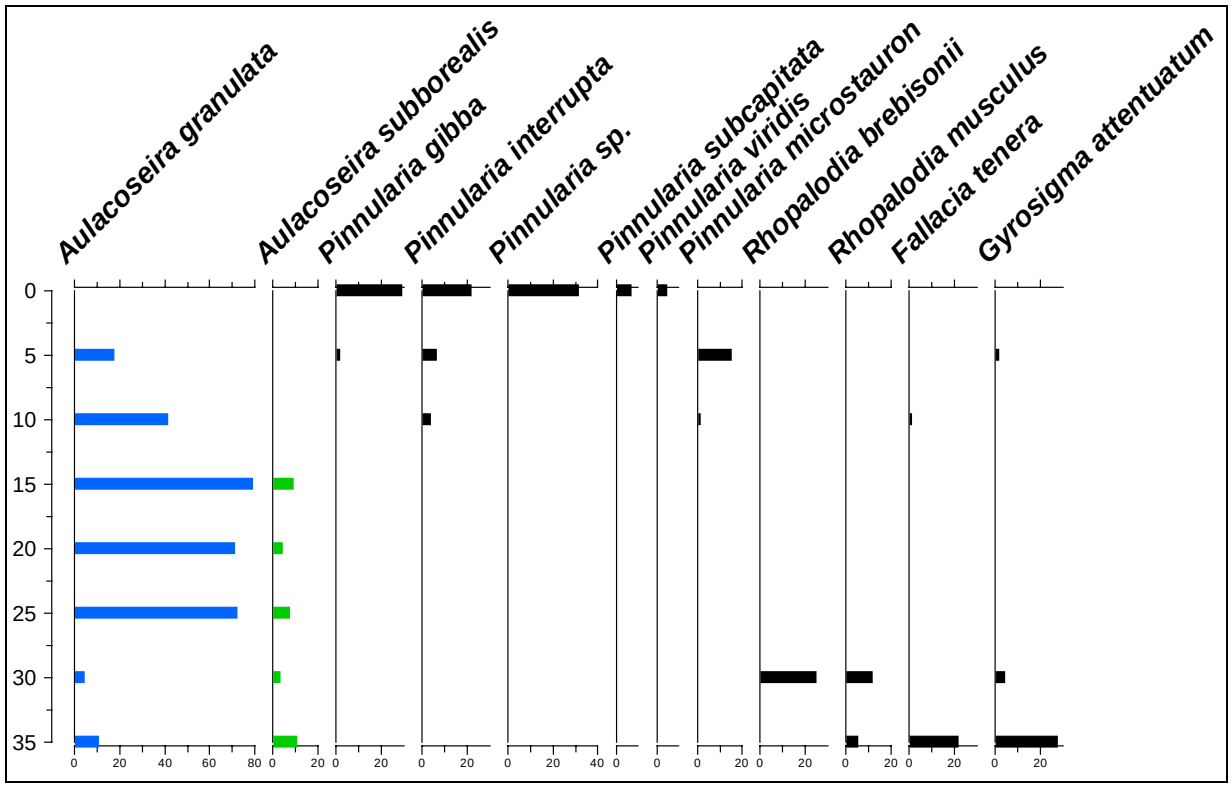
APPENDIX 3. Map of groundwater table levels in Martin Bend.

Includes depth below ground (DTW) and elevation (RSWL) of groundwater table .Source: River Murray Wetlands Baseline Survey (SKM 2004). **Note**: The groundwater table levels for bores MB6 & MB7 may be incorrect and should not be used as a reference.



APPENDIX 4. Microalgal (diatom) assemblage recorded in Martin Bend

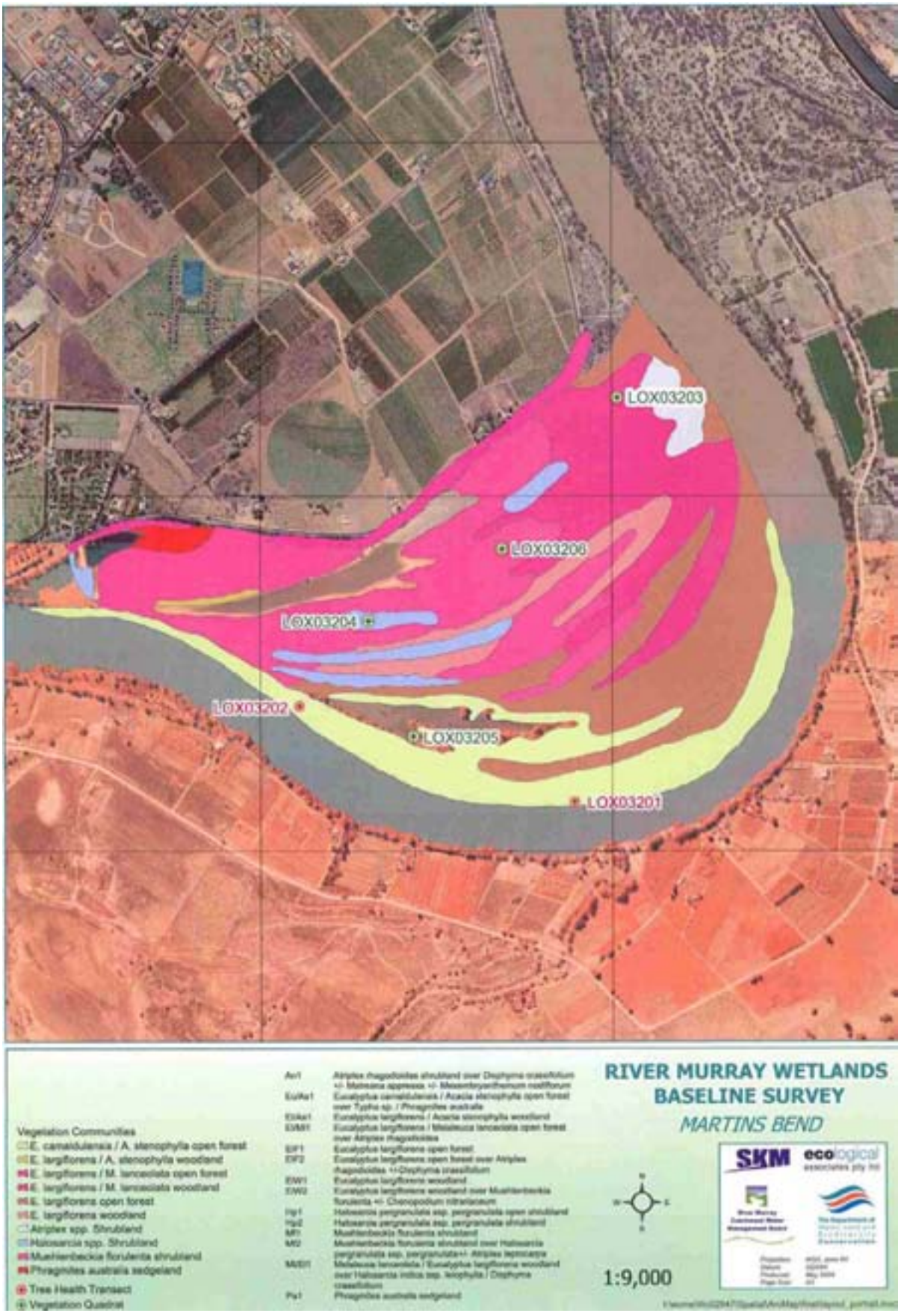
Appendix 4a: Microalgal (diatom) assemblage observed in a 35cm sediment core taken from the permanent lagoon in Martin Bend (Source: J. Fluin pers. comm. 2006).



Notes:

- Core depth in cm (below ground surface) is shown on vertical axis (y-axis)
- A 35cm sediment core was extracted from the site
- At the time of coring the water level was < 30cm
- Diatom assemblage (species names and species abundance) is shown on horizontal axis (x-axis)

APPENDIX 5. Vegetation Associations in Martin Bend



APPENDIX 6. List of flora recorded in Martin Bend

Scientific Name	Common Name	Source			Conservation Status		
		1	2	3	SA CS	SA PS	NAT
Native species							
Acacia stenophylla	River Cooba		+	+			
Atriplex lindleyi ssp. lindleyi	Baldoo	+					
Atriplex rhagodioides	River Saltbush	+					
Atriplex sp.	Saltbush		+				
Austrostipa sp.	Spear Grass			+			
Azolla sp.	Azolla			+			
Carpobrotus sp.	Pigface		+				
Charophyte (Family)				+			
Cotula coronopifolia	Waterbuttons			+			
Cressa cretica	Rosinweed	+					
Cyperus gymnocaulos	Spiny Flat-sedge			+			
Disphyma crassifolium ssp. *clavellatum*	Round-leaf Pigface	+		+			
Einadia nutans ssp. *nutans*	Climbing Saltbush			+			
Enchylaena tomentosa var. *tomentosa*	Ruby Saltbush	+		+			
Eremophila divaricata ssp. divaricata	Spreading Emubush	+					
Eucalyptus camaldulensis	River Red Gum	+	+	+			
Eucalyptus largiflorens	Black Box	+	+	+			
Halosarcia indica ssp. leiostachya	Brown-head Samphire	+					
Halosarcia pergranulata	Black-seed Samphire	+					
Lemna sp.	Duckweed			+			
Ludwiga peploides ssp. *montevidensis*	Water Primrose			+			
Melaleuca lanceolata ssp. lanceolata	Dryland Tea-tree	+	+				
Myriophyllum sp.	Water Milfoil			+			
Muehlenbeckia florulenta	Lignum	+	+	+			
Paspalum distichum	Water Couch	+					
Phragmites australis	Common Reed	+		+			
Sarcocornia sp.	Samphire		+				
Sclerolaena muricata var. muricata	Five-spine Bindyi	+					
Senecio glossanthus	Annual Groundsel	+					
Senecio lautus	Variable Groundsel	+					
Sporobolus mitchellii	Rat-tail Couch	+					
Typha domingensis or *T. orientalis*	Cumbungi	+		+			
Introduced species							
Avena sp.	Wild Oats			+			
Cuscuta campestris	Golden Dodder			+			
Gazania linearis	Gazania	+					
Lycium ferocissimum	African Boxthorn			+			
Mesembryanthemum nodiflorum	Slender Iceplant	+					
Salix sp.	Willow			+			
Sonchus oleraceus	Common Sow-thistle	+					
Xanthium occidentale	Noogoora Burr			+			

Conservation status based on the *2003 Review of the Status of Threatened Species in South Australia* (NPWC & DEH 2003) and the *Environment Protection and Biodiversity Conservation Act 1999*.

Key:

CS - Current status of threatened flora in schedules declared under the *National Parks and Wildlife Act 1972*
PS - Proposed of threatened flora following revisions to the schedules
NAT - National listings

Source:

1 - River Murray Wetlands Baseline Survey (SKM 2004)
2 - Martin Bend Wetland Management Plan (ID&A Pty Ltd 1998)
3 - Incidental/miscellaneous records for Martin Bend

Note: The vegetation associations surveyed in the Baseline Survey were:

- *Phragmites australis* Closed Grassland
- *Halosarcia pergranulata* Low Shrubland
- *Muehlenbeckia florulenta* Shrubland over *Halosarcia pergranulata* and *Atriplex lindleyi*
- *Melaleuca lanceolata / Eucalyptus largiflorens* Very Low Woodland over *Halosarcia indica*

APPENDIX 7. Examples of photopoints used to monitor vegetation in Martin Bend.

Photopoint: MAR PP02 (110°) 22/03/2004

3/11/2005

Photopoint: MAR PP03 (40°) 22/03/2004

3/11/2005

APPENDIX 8. List of fauna recorded in Martin Bend

Common Name	Scientific Name	Source			Conservation Status		
		1	2	3	SA CS	SA PS	NAT
Mammals (Introduced)							
European Rabbit	*Oryctolagus cuniculus*		+	+			
Fish (Introduced)							
Carp	*Cyprinus carpio*		+				
Frogs (Native)							
Barking Marsh Frog	*Limnodynastes fletcherii*		+				
Eastern Banjo Frog	*Limnodynastes dumerilii*	+	+				
Eastern Sign-bearing Froglet	*Crinia parinsignifera*	+	+				
Peron's Tree Frog	*Litoria peronii*		+				
Spotted Grass Frog	*Limnodynastes tasmaniensis*	+	+				
Southern-bell Frog	*Litoria raniformis*		+		V	V	Vu
Reptiles (Native)							
Shingleback	*Tiliqua rugosa*		+				
Birds (Native)							
Australian Magpie	*Gymnorhina tibicen*		+	+			
Australian Pelican	*Pelecanus conspicillatus*		+	+			
Australian Wood Duck	*Chenonetta jubata*		+				
Baillon's Crake	*Porzana pusilla*	+			R		
Black Swan	*Cygnus atratus*		+	+			
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*			+			
Black-fronted Dotterel	*Elseyornis melanops*	+	+	+			
Black-tailed Native-hen	*Gallinula ventralis*	+		+			
Black-winged Stilt	*Himantopus himantopus*	+					
Blue Wren	*Malurus cyaneus*			+			
Brown Treecreeper	*Climacteris picumnus*			+			
Crested Pigeon	*Ocyphaps lophotes*			+			
Darter	*Anhinga melaongaster*		+	+			
Dusky Woodswallow	*Artamus cyanopterus*			+			
Eurasian Coot	*Fulica atra*		+	+			
Galah	*Cacatua roseicapilla*			+			
Great Cormorant	*Phalacrocorax carbo*			+			
Great Egret	*Ardea alba*		+				C
Grey Shrike-thrush	*Colluricincla harmonica*			+			
Grey Teal	*Anas gracilis*	+	+				
Laughing Kookaburra	*Dacelo novaeguineae*		+	+			
Little Black Cormorant	*Phalacrocorax sulcirostris*		+	+			
Little Corella	*Cacatua sanguinea*			+			
Little Friarbird	*Philemon citreogularis*		+				
Little Grassbird	*Megalurus gramineus*			+			
Little Pied Cormorant	*Phalacrocorax melanoleucos*		+	+			
Magpie-lark	*Grallina cyanoleuca*			+			
Masked Lapwing	*Vanellus miles*	+		+			
Noisy Miner	*Manorina melanocephala*		+				
Pacific Black Duck	*Anas superciliosa*	+	+	+			
Peaceful Dove	*Geopelia striata*			+			
Pied Cormorant	*Phalacrocorax varius*		+	+			
Purple Swamphen	*Porphyrio porphyrio*	+	+	+			
Rainbow Bee-eater	*Merops ornatus*			+			
Red-capped Plover	*Charadrius ruficapillus*			+			
Red-kneed Dotterel	*Erythrogonys cinctus*	+		+			
Red-rumped Parrot	*Psephotus haematonotus*			+			
Richard's Pipit	*Anthus novaeseelandiae*			+			
Sacred Ibis	*Threskiornis aethiopica*		+	+			

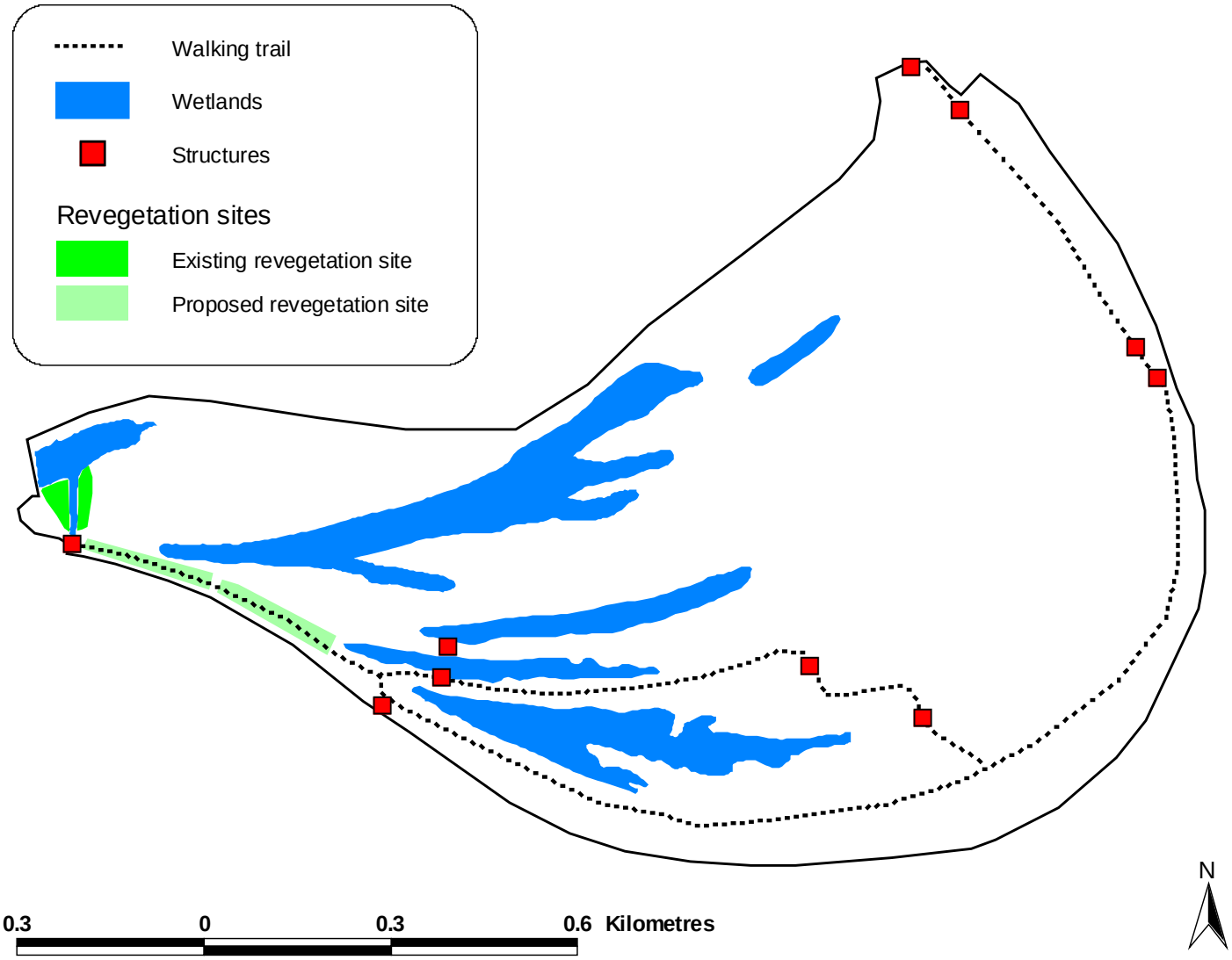
Common Name	Scientific Name	Source			Conservation Status		
		1	2	3	SA CS	SA PS	NAT
Scared Kingfisher	*Todiramphus sancta*			+			
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*			+			
Wedge-tailed Eagle	*Aquila audax*		+				
Welcome Swallow	*Hirundo neoxena*			+			
Whistling Kite	*Milvus sphenurus*			+			
White-faced Heron	*Egretta novaehollandiae*	+	+	+			
White-plumed Honeyeater	*Lichenostomus penicillatus*			+			
Willie Wagtail	*Rhipidura leucphyrs*			+			
Yellow Rosella	*Platycercus elegans*			+			
Yellow-billed Spoonbill	*Platalea flavipes*			+			
Zebra Finch	*Poephila guttata*			+			

South Australian conservation status follows (NPWC & DEH 2003).

Key:
SA CS - Current status of threatened fauna in schedules declared under the *National Parks and Wildlife Act 1972*
SA PS - Proposed status of threatened fauna following revisions to the schedules
NAT - National listings
R - rare in South Australia
V - vulnerable in South Australia
Vu - vulnerable under the *EPBC Act*
C - Listed under the China Australia Migratory Bird Agreement (CAMBA)

Source:
1 - River Murray Wetlands Baseline Survey (SKM 2004)
2 - Incidental/miscellaneous records for Martin Bend
3 - L. Geelen (personal observations) 19 January 2006

APPENDIX 9a. Location of the walking trail and revegetation areas in Martin Bend.



APPENDIX 9b. Revegetation recommendations for Martin Bend.

GREENING AUSTRALIA TECHNICAL ADVICE SHEET

Property Owner(s):

Contact Details:

Date: 11/04/06

Location: Martin Bend, Berri

PURPOSE/PROJECT

Species list for revegetation of a stormwater retention pond and walking trail. Aim is to create a wetland environment with a focus on planting native vegetation to attract wildlife (eg. birds)

DETAILS

REVEGETATION SPECIES

Species suitable for the area surrounding the stormwater pond:

Species Name	Common Name	Comments
Acacia stenophylla	River cooba	Plant within around 10m of the water
Atriplex rhagodioides	River saltbush	Low lying areas away from the water
Callistemon brachyandrus	Prickly bottlebrush	Low or high ground
Eremophila bignoniiflora	Bignonia emubush	Higher ground
Eremophila divaricata	Spreading emubush	Low lying areas away from the water
Eucalyptus camaldulensis	River redgum	Low lying areas near the water
Eucalyptus largiflorens	Black box	Low or high ground
Melaleuca lanceolata	Dryland tea-tree	Higher ground
Myoporum montanum	Native myrtle	Low or high ground
Myoporum parvifolium	Creeping boobialla	Low or high ground

Species more suited to the areas along the walking track include:

SpeciesName	Common Name	Comments
Acacia stenophylla	River cooba	Nearer the water is better
Atriplex rhagodioides	River saltbush	Good for understorey structure
Callistemon brachyandrus	Prickly bottlebrush	Spread out
Eremophila bignoniiflora	Bignonia emubush	Good for attracting birds
Eremophila divaricata	Spreading emubush	Good for understorey structure
Melaleuca lanceolata	Dryland tea-tree	Spread out – not many needed

ADDITIONAL INFORMATION

Watering

Watering will increase the survival rate of tubestock considerably. Each plant will need to be watered-in at planting time, preferably with 5-9L each. Options for watering include dripper systems (over large areas you may wish to rotate the drippers to different areas) and pulse watering over summer (this involves giving each plant 5-9L by bucket or hose at intervals of 2-4 weeks). Overhead irrigation is NOT suitable for revegetation, particularly in remnant vegetation as it

will encourage weeds to establish. Another option is to use water-saving crystals which are a good option in particularly dry years or where follow-up watering is not possible (water –saving crystals are a synthetic polymer which is hydrated and placed in the hole in contact with the plant roots – the water then leaches out slowly).

Timing of Planting

Regardless of whether watering is planned, tubestock should be planted as soon as there is adequate soil moisture. This will generally be around late May into June after the first few decent rains. Getting them in early ensures that there is good probability of further rains.

Local Provenance Tubestock

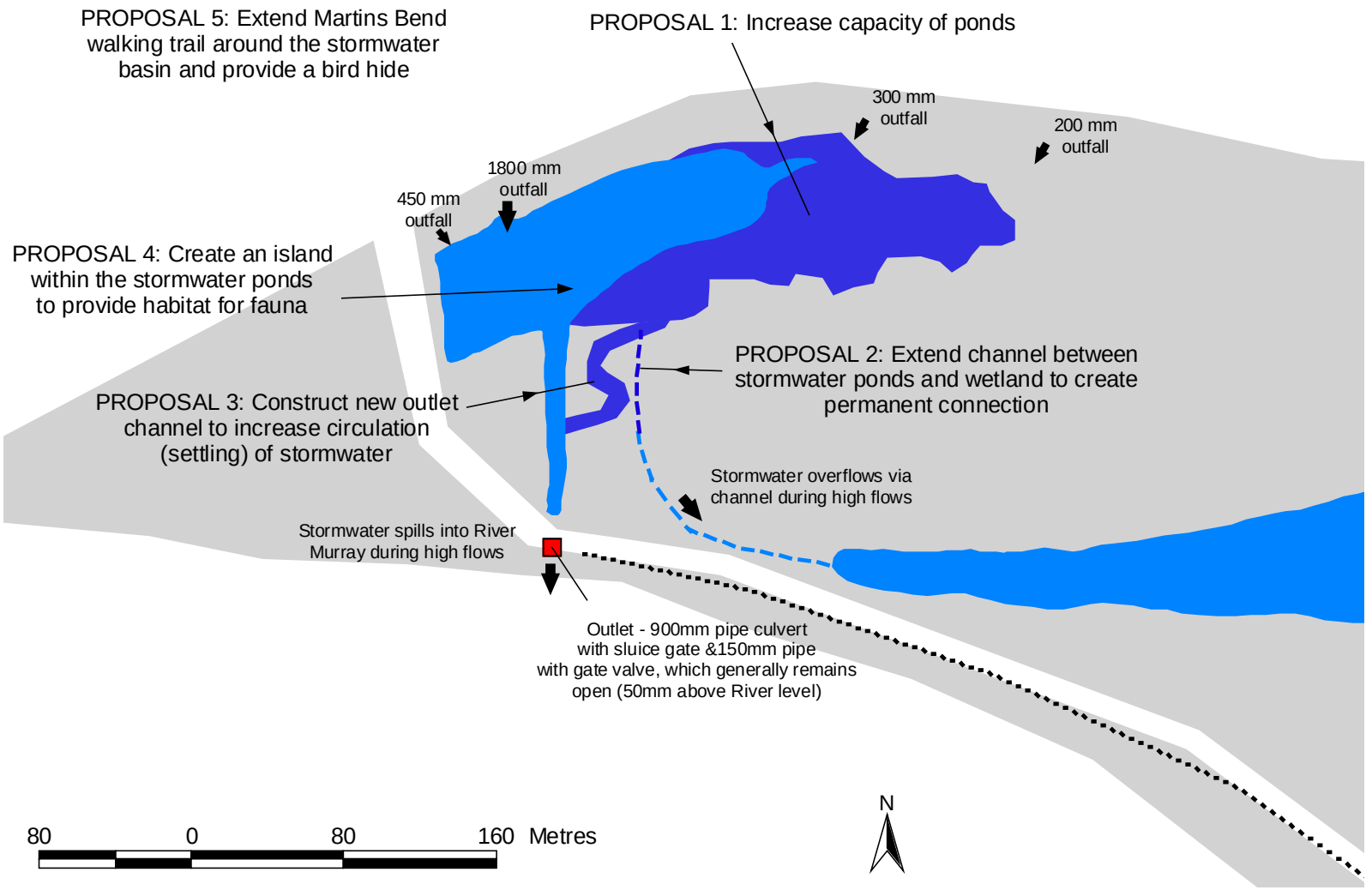
If you are intending to buy tubestock it is always best to contact the nursery late in the preceding year to allow local seed to be collected. If growing plants yourself then local provenance guidelines should be observed in seed collection.

OTHER CONSIDERATIONS

Rabbits

The effective control of rabbits prior to planting will increase the success of any revegetation considerably and will promote natural regeneration. If rabbits are still present at the time of planting, it will be necessary to use tree guards (which can also exclude kangaroos). Rigid coreflute guards that use a single wooden stake are a good option for keeping rabbits out.

APPENDIX 10. Proposed works to stormwater ponds in Martin Bend



APPENDIX 11. Key stages in wetland water regime management.

Summary of the key stages in wetland water regime management - summarised from *Your Wetland: Hydrology Guidelines* (Tucker *et al*. 2002).

Drying the wetland

Complete drying of the wetland is beneficial to the wetland as it provides ideal conditions for the germination of dry wetland bed plants. These plants then go on to provide shelter for fish and macroinvertebrates once the wetland is re-filled. Nutrients from these plants will also be released into the water to be available for use by other emergent and submerged plants. When the wetland has been dried for six months or longer, the wetland bed sediments can be consolidated and therefore the sediments will not be re-suspended when the wetland is filled. Also with this extended dry period, some native plants are able to complete their life cycles and release their seed into the seed bank for germination on the next drying event. Drying the wetland will also help to reduce carp numbers. Large carp will be stranded by the loss of water and die or be eaten by birds. Carp eggs that are laid around the fringes of the wetland will die when dried out.

Drying of a wetland should best commence in late summer and last until early spring. The decision to dry a wetland should also be dependant on the submerged vegetation. The wetland should contain water until this vegetation has flowered and set seed. Monitoring can determine when is the correct time for drying to begin.

Filling the wetland (pool level)

When wetlands are filled after being dry for a period of time there are a number of benefits to the wetland ecosystem. When water re-enters the wetland the consolidated sediments are not re-suspended, which allows light to penetrate through the water column and support the germination of aquatic plant species. These plants provide food and habitat for aquatic fauna. Re-filling after drying also evokes the release of nutrients from sediment, which are taken up by algae and plants.

Wetlands should be filled slowly, typically during spring. The wetland should remain full for at least one growing season (spring to the end of summer) to allow aquatic plants, to complete their life cycle and set seed. Inundation for two growing seasons is preferable. Filling can also support the longer lived vegetation such as the Black box and River Red Gums as well as creating or improving a freshwater lens under the wetland. Salinity levels in the lagoon can also be lowered through the influx of fresh water diluting the salts.

Partial drying of the wetland

Partial drying of the wetland involves lowering the water level in the wetland. The advantage of a partial dry is that by exposing the sediment, emergent vegetation has greater area to grow. Partial drying also favours species that respond to a fluctuating water level. However, reducing the water level can also have negative impacts by promoting the spread of undesired plant species

Over bank flooding

The final management phase is over bank flooding. This involves holding water in the wetland higher than pool level. The affects of flooding are well documented with the most significant impacts being on the riparian zone vegetation such as River Red Gums. Currently, over bank floods only occur in Martin Bend during flood events in the River Murray when the river is significantly higher that the water level maintained by the locks and weirs.

APPENDIX 12. Martin Bend Wetland Operational Plan - water volume calculation.

The following calculation was used to determine the volume of water in the Wetland Operational Plan for Martin Bend (permanent lagoon only).

Martin Bend did not have an existing temporary water licence (as of April 2006). However, the wetland may not be completely dry before filling due to the water remaining from rainfall, and possibly due to groundwater seepage.

Background data:

- Surface area of permanent lagoon when inundated to Lock 4 pool level (13.20 mAHD) = ~ 5 ha
- Volume to fill the permanent lagoon from dry to Lock 4 weir pool level = ~ 15 ML (based on average water depth of 0.3 m)
- Net loss (evaporation minus precipitation) of water from Martin Bend determined using Wetland Loss Calculator developed by DWLBC.

Water Volume Calculation (Permanent Lagoon only)

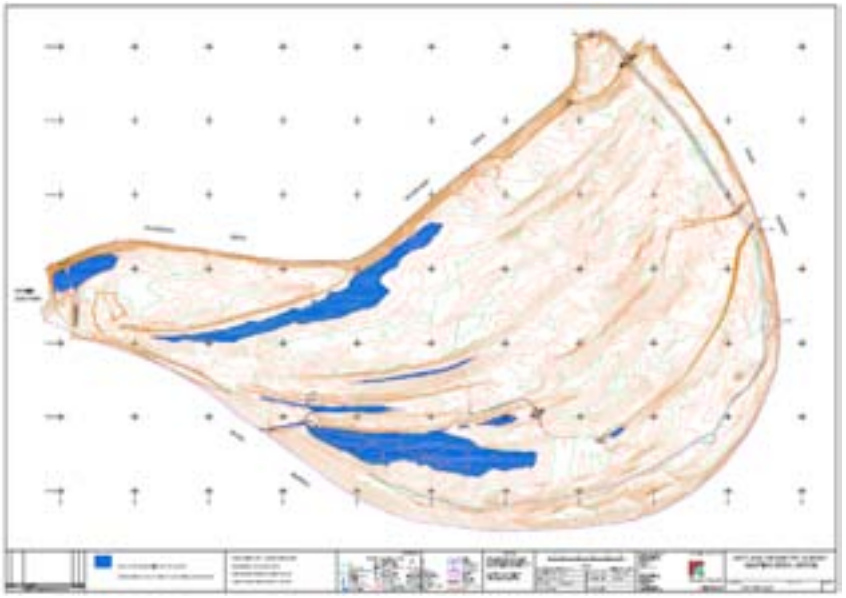
Year	Period	Action	Details	Water use (ML)
2005/2006	1 July 2005 – 19 September 2005	Dry wetland	-	0 ML
	20 September 2005 - 2 November 2005	Weir manipulation and pumping	Approximately 120 ML water entered wetland	No water licence was required
	3 November 2005 - 30 June 2006	Dry wetland	-	0 ML
2006/2007	1 July 2006 to 30 September 2006	Dry wetland	-	0 ML
	1 October 2006 to 30 June 2007	Fill wetland to pool level	Fill (15 ML), Evaporation (65 ML)	80 ML
2007/2008	1 July 2007 to 30 January 2008	Maintain water level at pool level	Evaporation (50 ML)	50 ML
	1 February 2008 - 30 June 2008	Dry wetland	-	0 ML
2007/2008	1 July 2008 - 31 October 2008	Dry wetland	-	0 ML
	1 November - 30 June 2008	Maintain water level at pool level	Fill (15 ML), Evaporation (60 ML)	75 ML
Total water volume (for the period 1 July 2005 - 30 June 2009)				**205 ML**

Note:

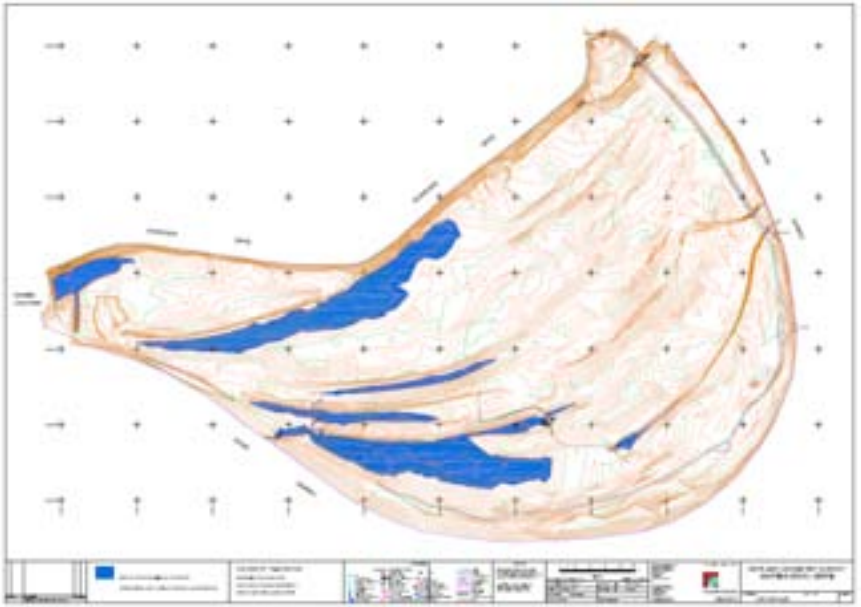
- All figures rounded to the nearest 5 ML.

- Approximately 140 ML of water is required to inundate the permanent and temporary lagoons up to a level of 14.20 mAHD (i.e. via pumping).

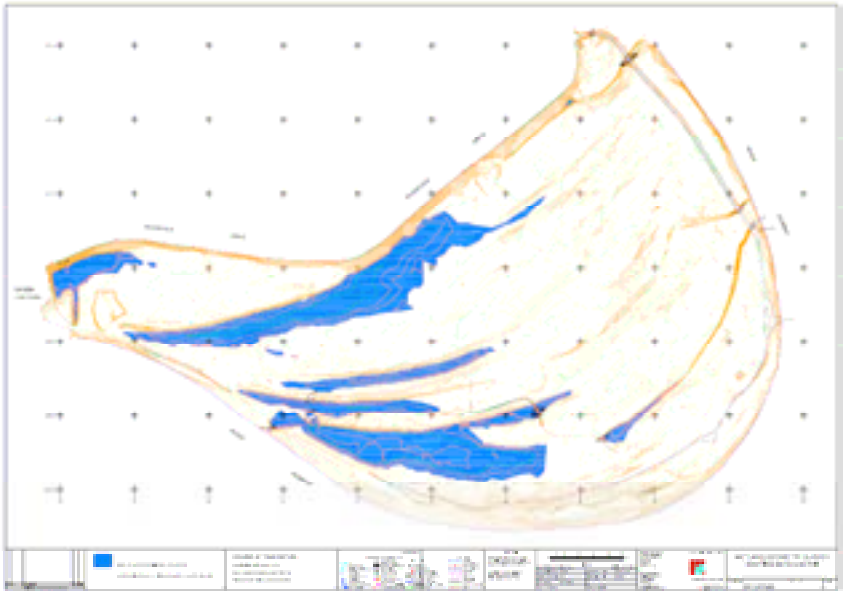
APPENDIX 13. Martin Bend elevation survey, showing areas of wetland inundation



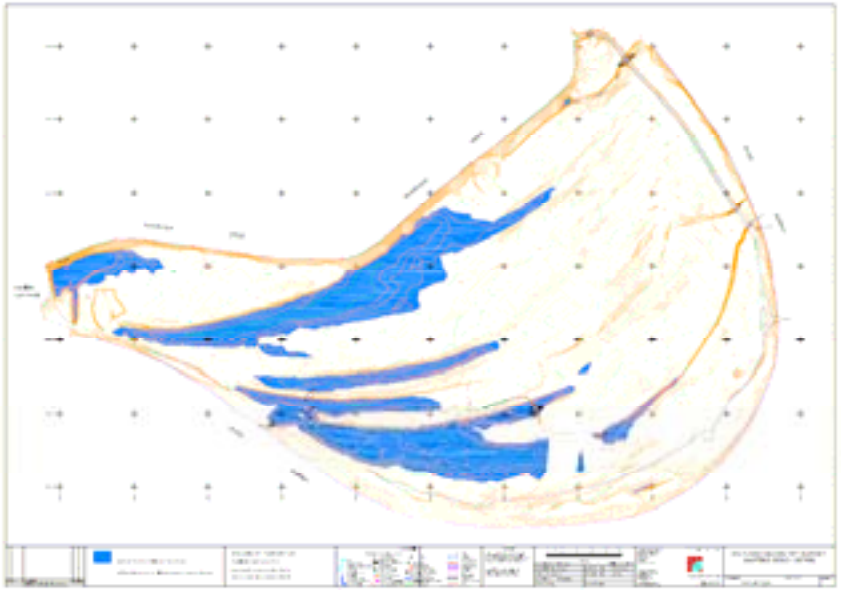
a) Area of wetland inundation at 13.20 mAHD.



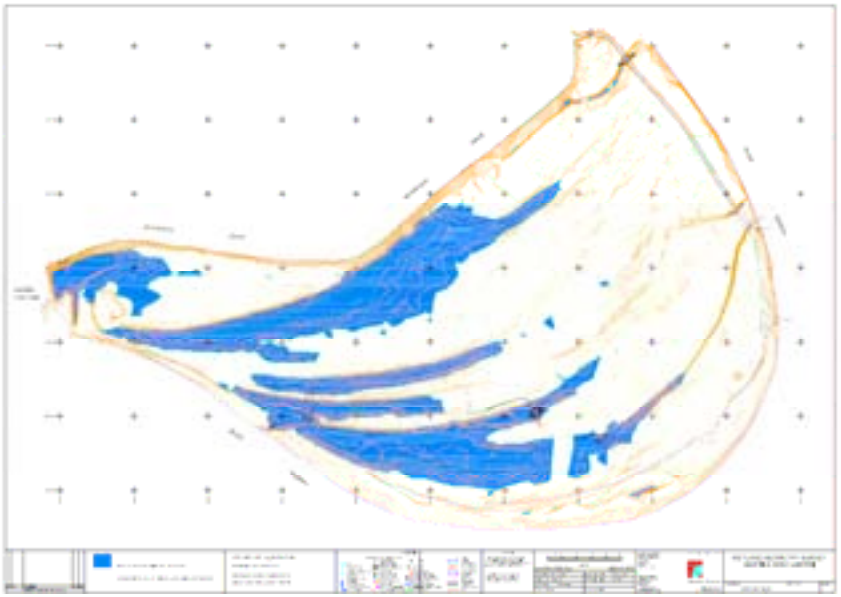
b) Area of wetland inundation at 13.40 mAHD.



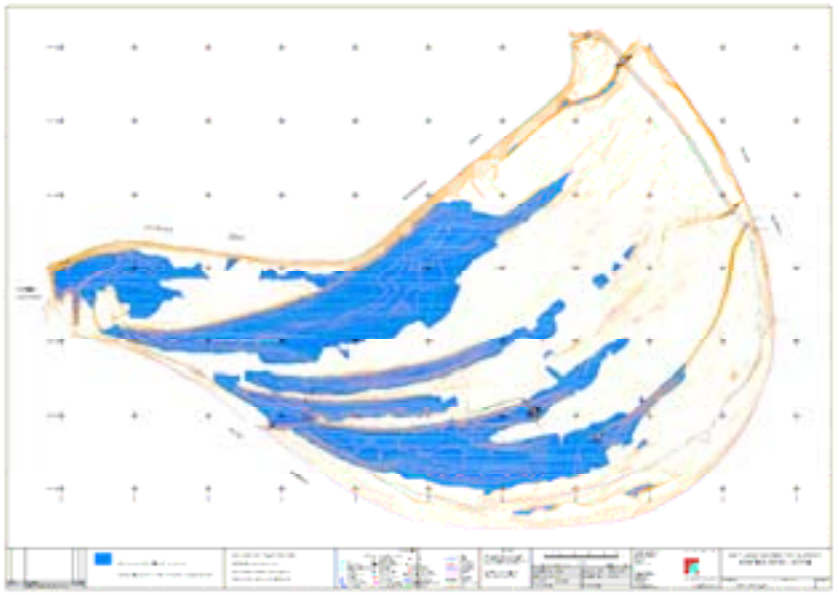
c) Area of wetland inundation at 13.60 mAHD.



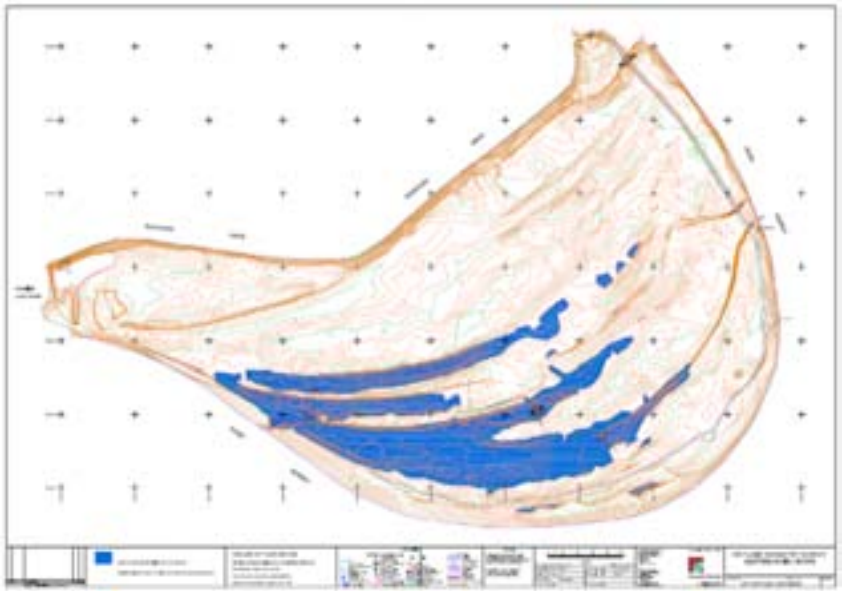
d) Area of wetland inundation at 13.80 mAHD.



e) Area of wetland inundation at 14.00 mAHD.



f) Area of wetland inundation at 14.20 mAHD.

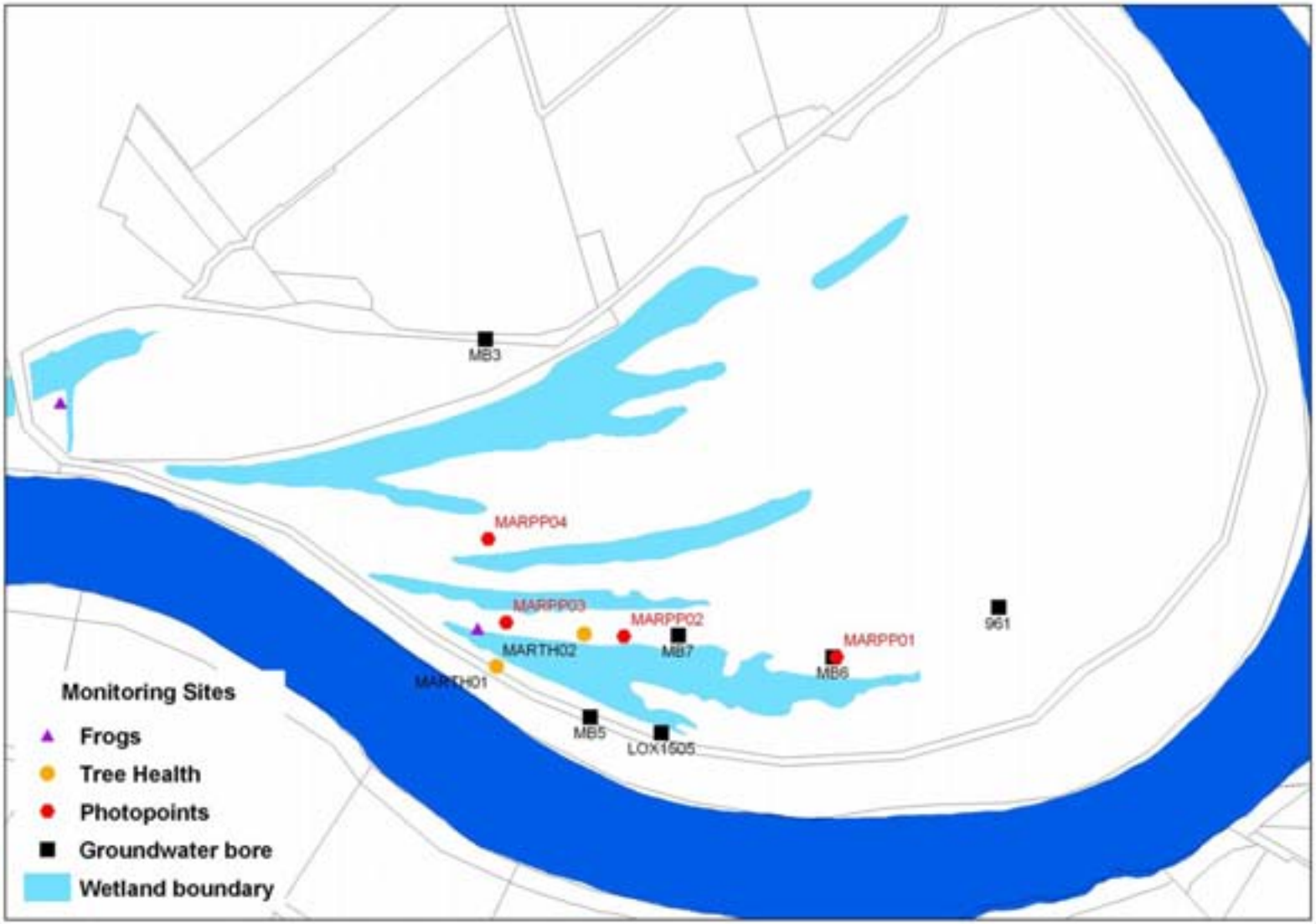


g) Area of wetland inundation at 14.20 mAHD (localised to the permanent and temporary lagoons (P1, T1 & T2), which are interconnected).

Note:

- Blue shading in these elevation contour maps indicates the area of wetland inundation.
- Each map shows wetland inundation to a different water level (e.g. 14.20 mAHD). *This assumes the wetland was completely full to begin with*.

APPENDIX 14. Martin Bend Monitoring Sites - Community Monitoring



APPENDIX 15. Aerial photograph of Martin Bend